Hubble's New Eyes on the Galaxy

ASTRONOMY®

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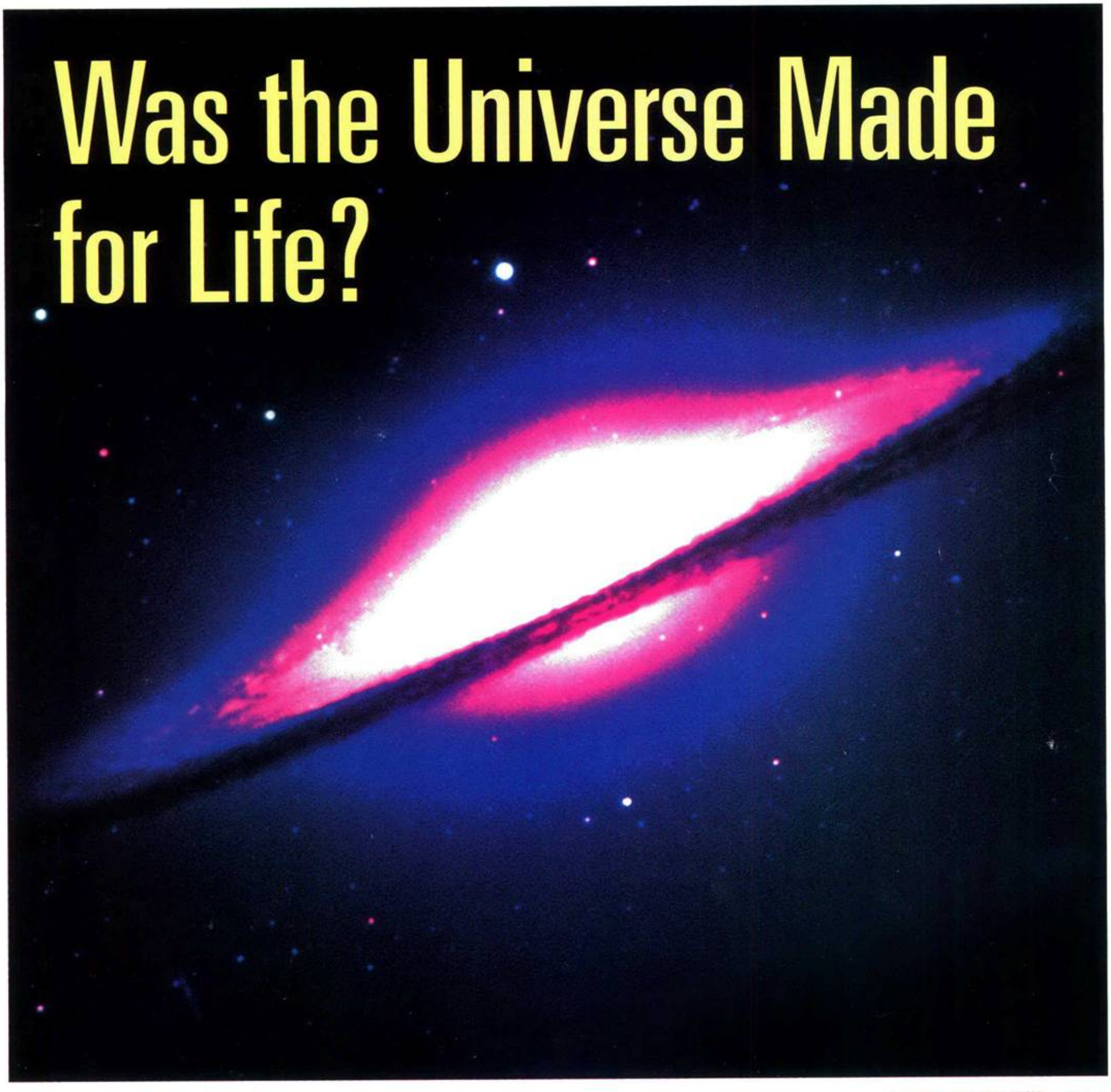
U.K. £2.25
Can. $5.25

ICD 08070

How Hot Stars Kill Off Planets



Was the Universe Made for Life?

- Building a Backyard Observatory
- Naked-Eye Moon Observing

LX50

Advanced technology at the most affordable prices *ever.*

■ Battery-Powered, Completely Cordless Operation! Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.

■ Standard-Equipment Declination Motor and Hand Controller: Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.

■ Multi-Function Control Panel: Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*. A North-South switch permits telescope operation anywhere in the world.

■ Super Multi-Coated Optics: The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

■ Massive LX200-type Fork Mounts: Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; MA25mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y	**1295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(right)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.

MEADE
MAGELLAN II
COMPUTER · CORRECTOR
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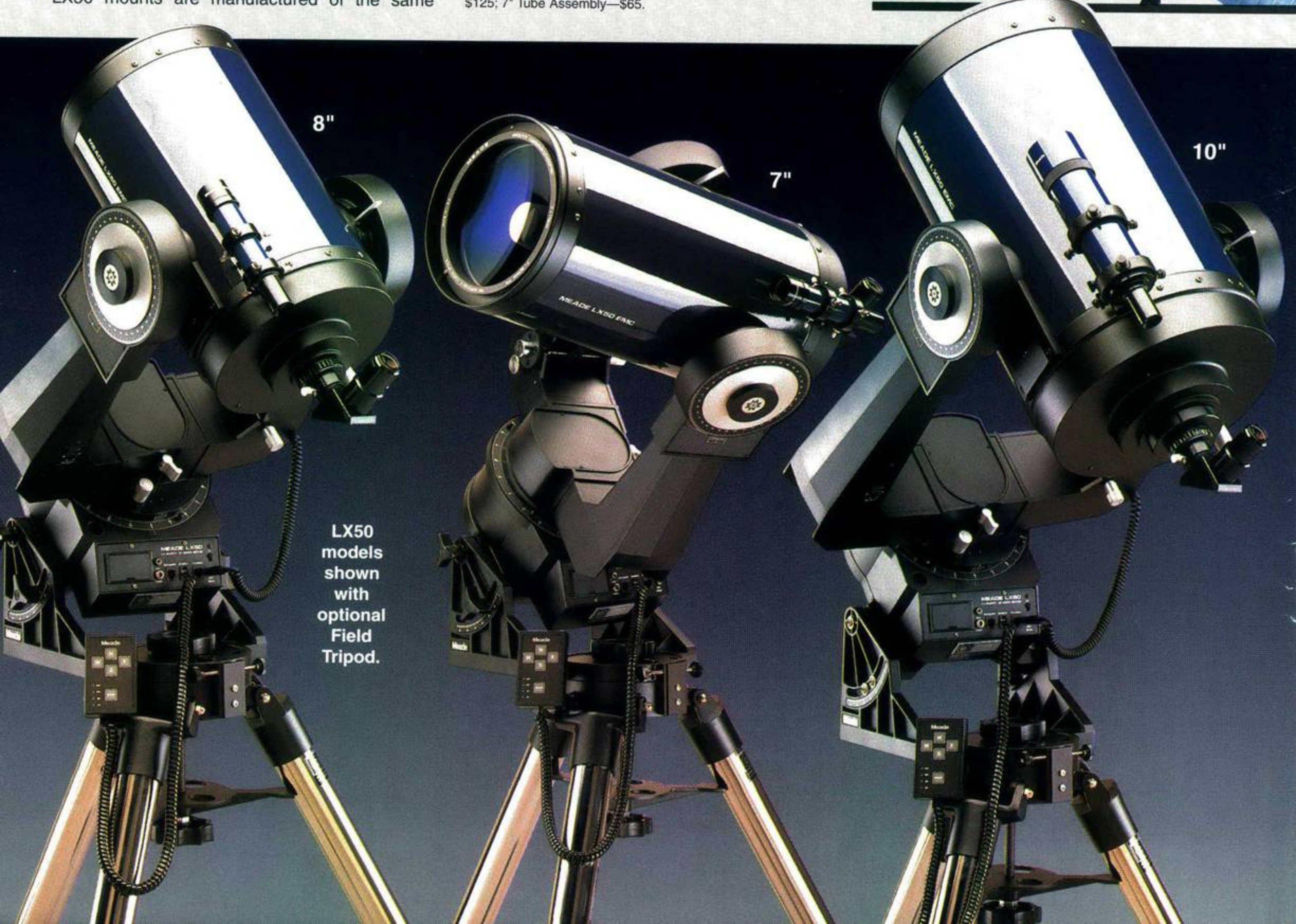
only $495!



LX50 models shown with optional Field Tripod.

The largest-selling serious telescopes in the world.

LX200

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models *combined*. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*
- **Meade LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an automobile cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states:
8"—$105; 10"—$145; 12"—$215;
7"—$125.

Write, call, or fax Meade Instruments for your free copy of the 94-page Meade 1997 General Catalog.

Prices shown are suggested U.S. mail-order retail prices.

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June 1997
Vol. 25, No. 6

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Clear, dark, and steady skies reward observers who trek to the European Southern Observatory at La Silla in the Chilean Andes. There, astronomers from throughout Europe come to push back the frontiers of modern astronomy. *Jorge Ianiszewski.*

Cover art
© European Southern Observatory

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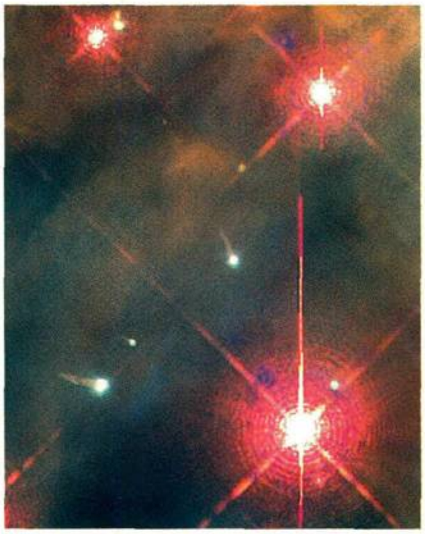
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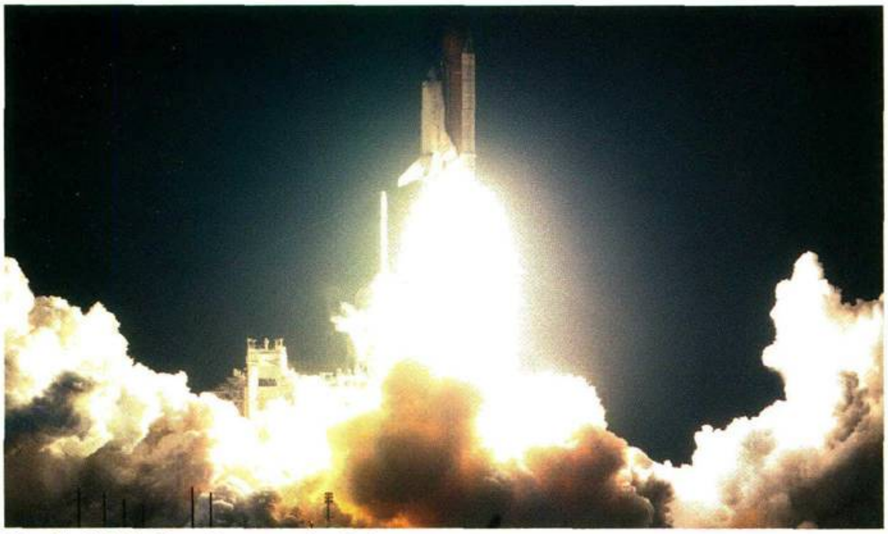
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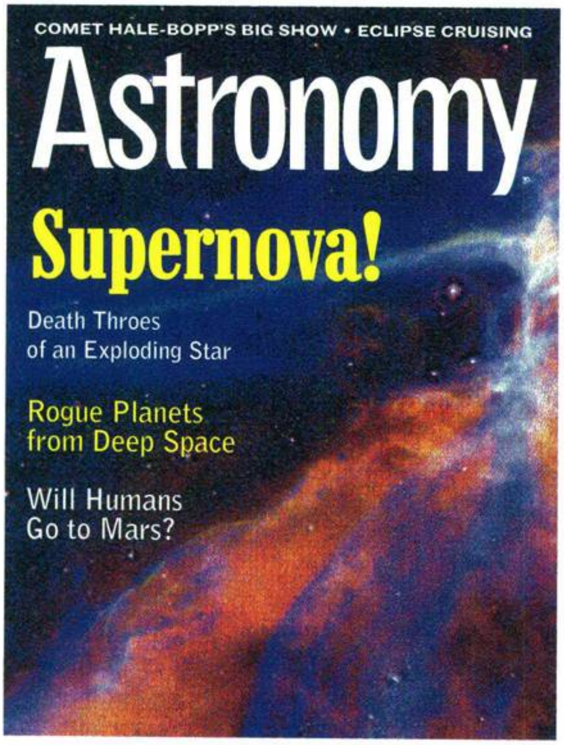
BEHIND THE SCENES

ASTRONOMY's New Face

One of ASTRONOMY's missions is to bring you information about change in the universe — and in how we understand it. In the past year, we've brought you several new planets, we have explained the evidence of and argument for life on Mars, and, in this issue, we will tell you about a new estimate for the universe's old age (see AstroNews on page 26).

To keep pace with the universe and to improve our ability to pass ideas on to you, we are constantly looking for ways to make the magazine better. As many of you have noticed, there are gentle changes arriving with almost every new issue of ASTRONOMY. The change that will arrive with your July issue will be a more obvious one. We have brought in a nationally celebrated magazine designer, Greg Paul, who has worked closely with our own talented art director, Carole Kramer, to bring a new look to ASTRONOMY.


COMET HALE-BOPP'S BIG SHOW • ECLIPSE CRUISING
Astronomy
Supernova!
Death Throes of an Exploding Star
Rogue Planets from Deep Space
Will Humans Go to Mars?

ASTRONOMY magazine gets a fresh look in the July 1997 issue.

We are working hard to make the words you read more elegant, entertaining, and information-rich. Our goal in July is to present you with a design that enhances those words. We are aiming for better ways to present photos and illustrations, more readable text, and more consistency throughout the issues. And we're also aiming for more joy.

You may never even notice the difference inside our pages, but I think you will notice one change right away. We are dropping our traditional cover border and giving you a big, full-frame image — a new welcome to the magazine.

Our design has served us very well for 24 years. Many of you have sent your compliments, but change is certain, and it's almost here. We want to keep evolving just as our subject does and just as do the tools of the trade and hobby.

Bonnie Bilyeu Gordon

Bonnie Bilyeu Gordon

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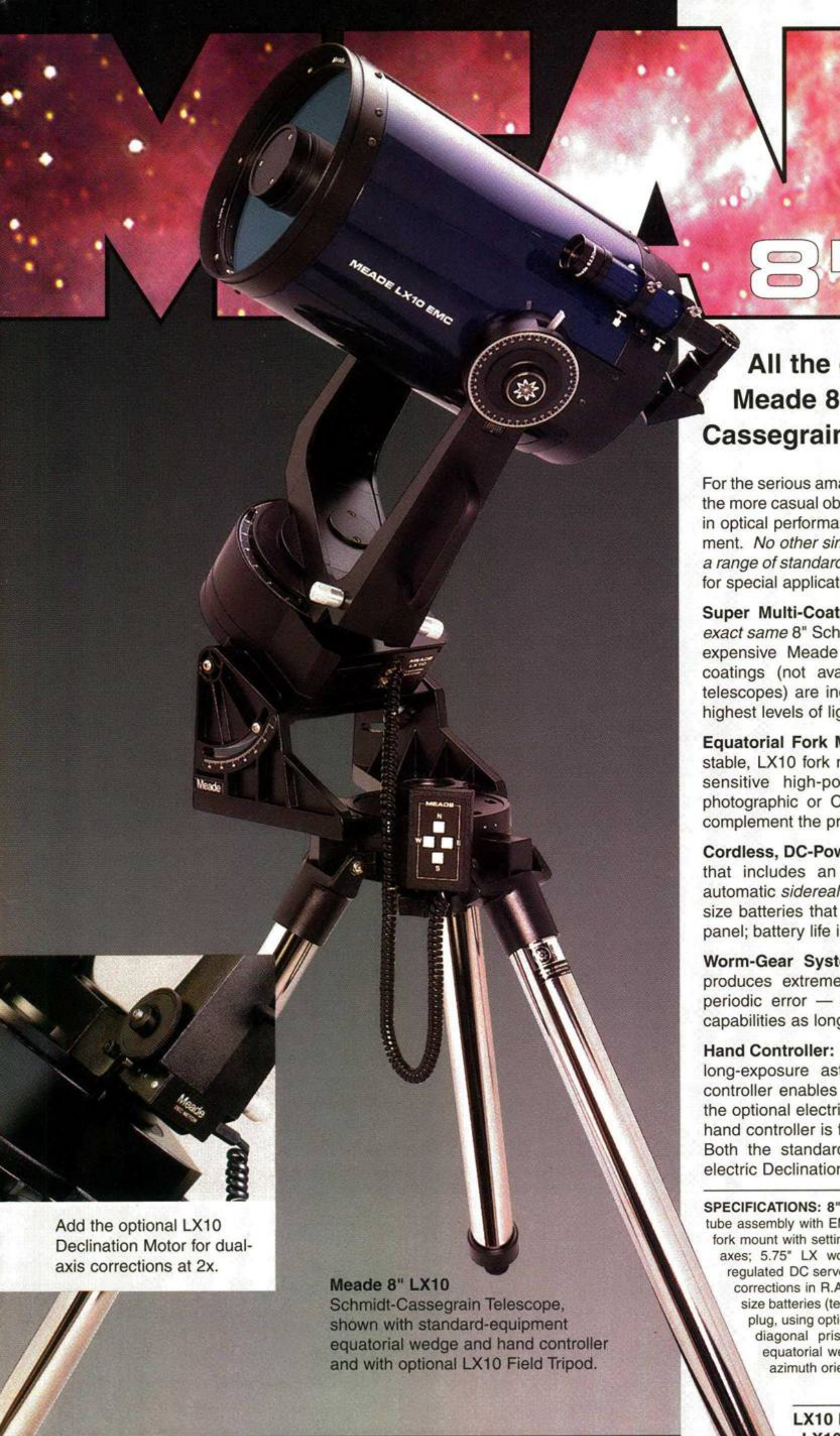
The Audit Bureau

MEADE 8" LX10



Add the optional LX10 Declination Motor for dual-axis corrections at 2x.

Meade 8" LX10
Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

All the optical performance of Meade 8" LX50 and LX200 Schmidt Cassegrains...for only *$995!*

For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *No other similarly-priced 8" Schmidt-Cassegrain offers such a range of standard features* — or such a range of important options for special applications. *Standard-equipment includes:*

Super Multi-Coated Optical System: The LX10 includes the *exact same* 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. Super multi-coatings (not available even as an *option* on competing 8" telescopes) are included with every LX10 optical system, for the highest levels of light transmission and image contrast.

Equatorial Fork Mounting: The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. Ball bearings on the polar axis complement the precise action of the internal worm gear system.

Cordless, DC-Powered Electronic Motor Drive: A drive system that includes an electronically-regulated DC servo motor for automatic *sidereal-rate* tracking. The drive is powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours.

Worm-Gear System: The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging.

Hand Controller: Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes. Both the standard-equipment hand controller and the optional electric Declination motor plug into the telescope's control panel.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); MA25mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions.
$995. (+ $65 packing & shipping in the 48 states)

LX10 Field Tripod	**195.**
LX10 Electric Declination Motor System	**85.**
#2014 Magellan I Telescope Computer System for LX10, with 12,218-object database	**375.**

The 94-page Meade 1996 General Catalog is available free of charge from Meade Instruments or from authorized Meade dealers. Prices shown are suggested U.S. mail-order prices.

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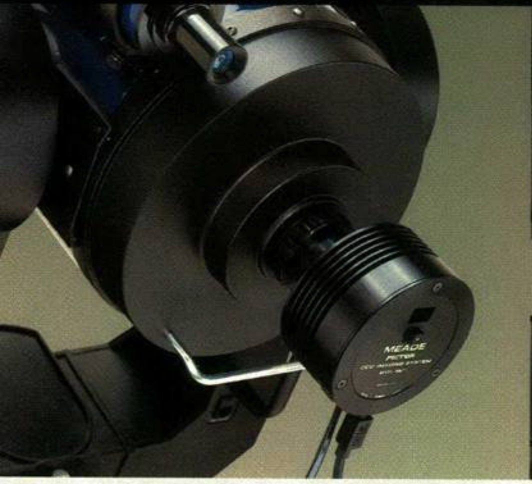
Meade Pictor 208XT

AUTOGUIDER/IMAGER

complete **$495**



Meade Pictor 216XT

AUTOGUIDER/IMAGER

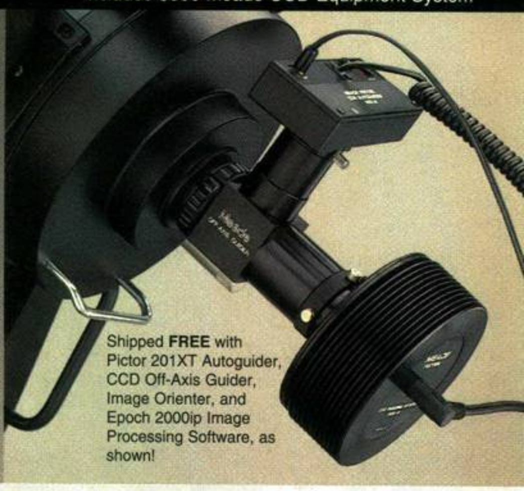
complete **$695**

Meade Pictor 416XT

AUTOGUIDER/IMAGER

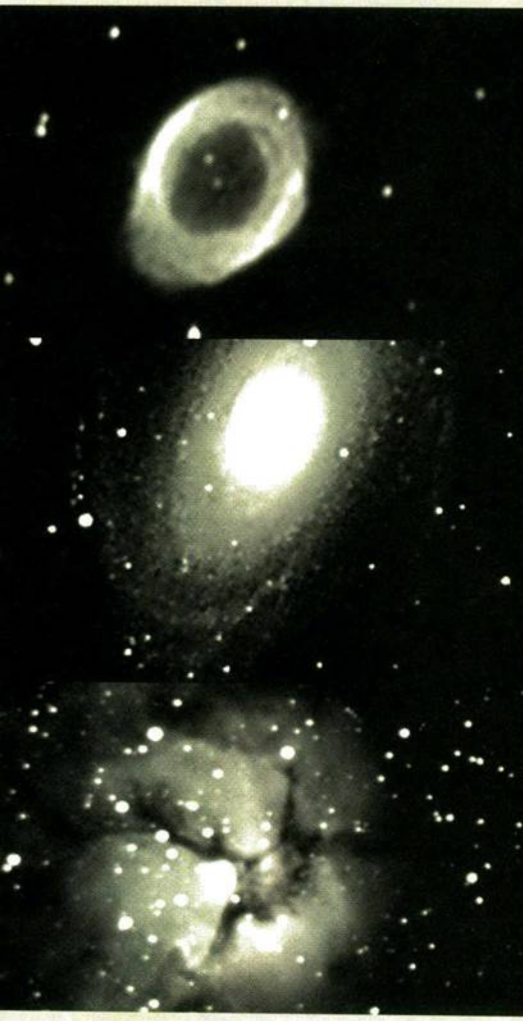
complete **$1695**

includes $800 Meade CCD Equipment System

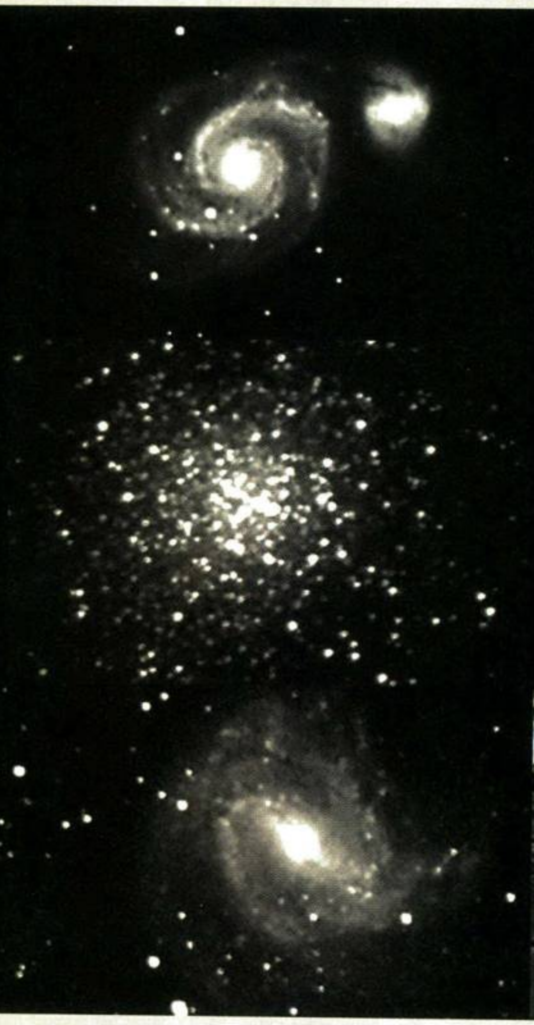


Shipped **FREE** with Pictor 201XT Autoguider, CCD Off-Axis Guider, Image Orienter, and Epoch 2000ip Image Processing Software, as shown!

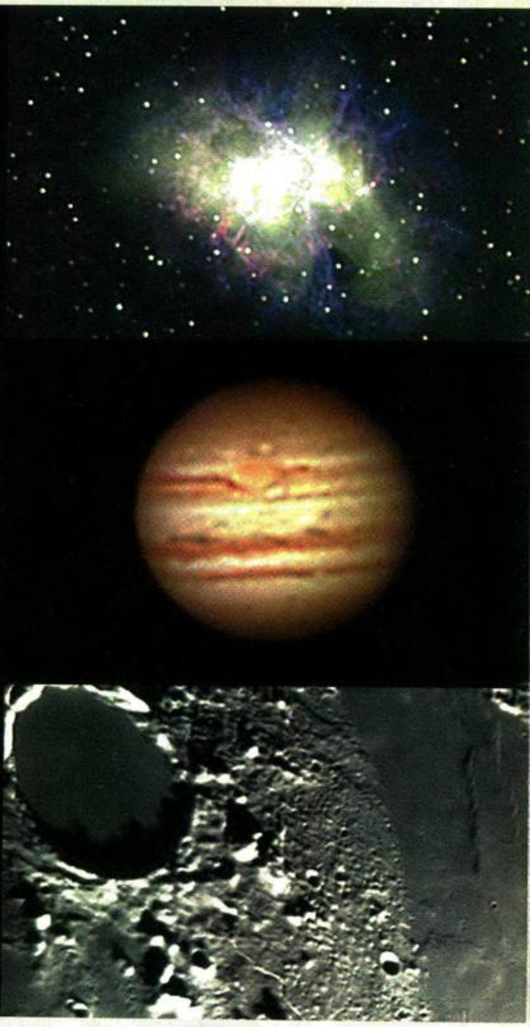
Revolutionary Meade Pictor CCD's are now the world's largest-selling autoguiders and imagers for the amateur astronomer. No other electronic imaging systems offer such an incredible range of capabilities at such amazing price levels. At only **$495** the **Pictor 208XT** produces on the PC display fine, high-resolution 8-bit images *in seconds* of the Moon and planets, or, in 2 or 3 minutes, of thousands of deep-space objects. At **$695** the **Pictor 216XT** enables advanced 16-bit imaging and is *by far* the finest autoguider/imager ever made available at under-$1000. At **$1695** the **Pictor 416XT** permits professional-level imaging capability for the amateur astronomer: an electronic camera capable of producing with amateur telescopes images of the Moon, planets, and deep-space that match or exceed the photographic images obtained with many observatory telescopes. All models are available for immediate shipment. ***For complete information on Meade CCD imaging systems write, call, or fax for your free copy of the 94-page Meade 1997 General Catalog.***



Pictor 208XT images *(top to bottom):* Ring Nebula (M57), 25" reflector, Jack Newton; Galaxy (M81) in Ursa Major, 12" LX200, Scott Roberts; Trifid Nebula (M20), 8" LX200, John Hoot.



Pictor 216XT images: Whirlpool Galaxy (M51), 12" LX200, John Hoot; Globular Cluster (M13), 25" reflector, Jack Newton; Galaxy (M83) in Hydra, 12" LX200, Scott Roberts.



Pictor 416XT images: Crab Nebula (M1), 25" reflector, Jack Newton; Jupiter, 10" LX200 with Stellar Products AO-2 seeing adapter, Dr. Donald Bruns; Moon (crater Plato), 16" f/6 reflector, Dr. Donald Parker.

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MEADE ETX

90mm Maksutov-Cassegrain

MEADE SUPER PLÖSSL
MEADE
MEADE

Meade ETX Astro Telescope. Shown with optional #64 Photo Adapter.

SPECIFICATIONS: ETX Astro Telescope— Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; equatorial fork mount with slow-motion controls, locks, and setting circles in R.A. and Dec; table tripod with elevation scale on center tripod leg; motor drive system with internal battery compartment accepting three (user-supplied) AA-size batteries; 8 x 21mm achromatic erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. *Net weight 9 lbs.* **$595***
(+ $20 packing and shipping in the 48 states)
*Suggested U.S. mail-order retail price.

Now you can have diffraction-limited imaging and ultraportability ...at only *$595*, *complete!*

The revolutionary Meade ETX goes anywhere with you at a moment's notice and presents the finest optical images ever made available in an ultraportable telescope.

Optical System: Manufactured at the Meade Irvine, California facility, ETX diffraction-limited optics produce images so high in contrast, brightness, and resolution that the ETX consistently outperforms telescopes of much larger apertures. **Equatorial Fork Mount:** Precise polar alignment in *seconds,* just by extending the center tripod leg to read your latitude on the inscribed scale. **Cordless Motor Drive:** The internal drive system operates from 3 AA-size batteries that power the motor drive for more than 50 hours. A North-South switch permits operation anywhere in the world. **Flip-Mirror System:** Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter. **Standard accessories** include a Series 4000 Super Plössl 26mm eyepiece and 8 x 21mm erect-image viewfinder.

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MEADE

STARFINDER DOBSONIANS

No other competing Dobsonians include this listing of *standard-equipment* features:

Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass: Unlike the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

Multi-Coated MA25mm Eyepiece (1.25"): The Meade Modified Achromatic 25mm eyepiece yields sharp, high-resolution imaging to the field edge.

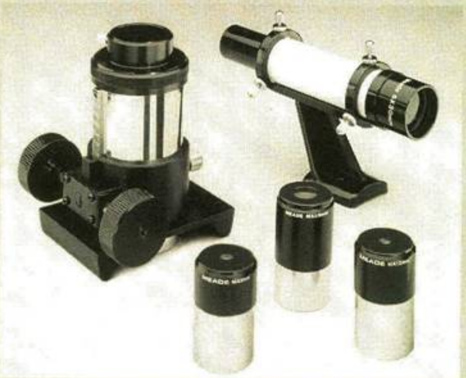
5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: Starfinder Dobsonians include the same strong, spiral-wound Sonotube™ optical tubes used on Starfinder Equatorials *(right)*, tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

Dobsonian Deluxe Accessory Package only $49.95!



Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

- **1 - Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*
- **1 - Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*
- **3 - Meade MA9mm, 12mm, and 25mm** multi-coated eyepieces, 1.25" barrel — eyepieces for the full range of lunar, planetary, and deep-space observing. *(reg. $37.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $223.75!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

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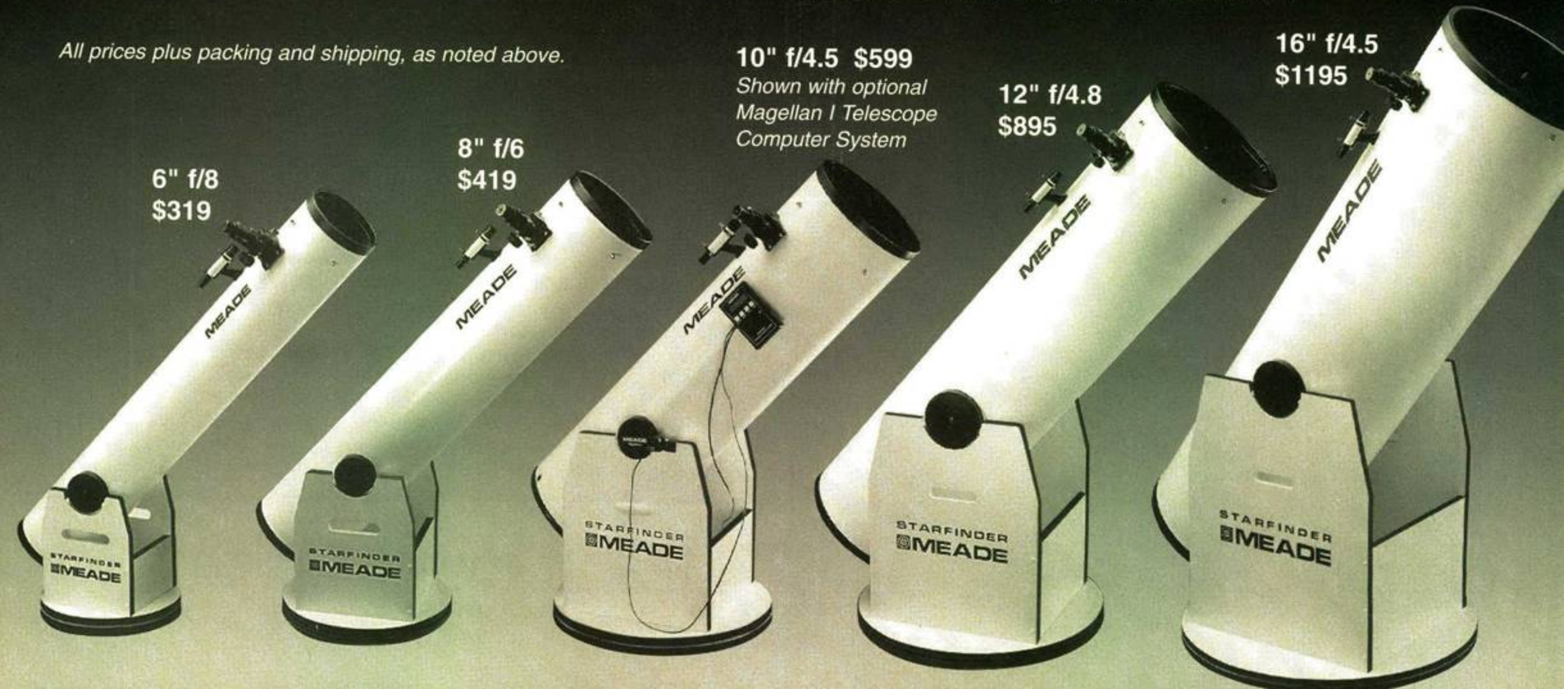
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

#2010: for Meade Starfinder Dobsonian
6", 8", 10", 12.5", or 16" . . . . $295.
Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES ***Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.***



All prices plus packing and shipping, as noted above.

6" f/8
$319

8" f/6
$419

10" f/4.5 $599
Shown with optional Magellan I Telescope Computer System

12" f/4.8
$895

16" f/4.5
$1195

MEADE
STARFINDER EQUATORIALS

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, ***for a total of $29.95!*** *Purchased separately, the 2 eyepieces sell for $75.90.*

The fullest exposition of Meade astronomical telescopes, CCD imagers, and telescope accessories is contained in the 94-page Meade 1997 General Catalog.

Write, call, or fax Meade Instruments for your free copy!

To Order: Contact your authorized Meade Advanced Products Dealer. Prices shown are suggested U.S.A. mail-order retail prices.

DC-powered drive systems for fully automatic tracking, and a wide range of standard-equipment features:

Professional-Grade Optical System: Includes hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! Provides fully automatic tracking of celestial objects. Operates for more than 50 hours from 6 (user-supplied) AA-size batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

Accessories and Components: #637 6 x 30mm viewfinder with wide 7° field; multi-coated MA25mm eyepiece (1.25"); strong, durable, spiral-wound optical tube with attractive white finish.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

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MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page).*

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" . . . . $295.
#2012: for Meade (DC-powered) Starfinder Equatorial 16" . . . . 295.

MEADE
MAGELLAN II
COMPUTER-CORRECTOR
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Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" . . 495.
#2019: for (DC-powered) Starfinder Equatorial 16". . . . . 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

AUTHORIZED U.S. MAIL-ORDER DEALERS

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE COMPANY, Burbank, CA.
Orders & Information: 818-505-8424.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; Illinois: 312-332-2000.

Canada:

EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

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16542 Millikan Avenue, Irvine, Calif. 92606 ☐ (714) 756-2291
FAX: (714) 756-1450

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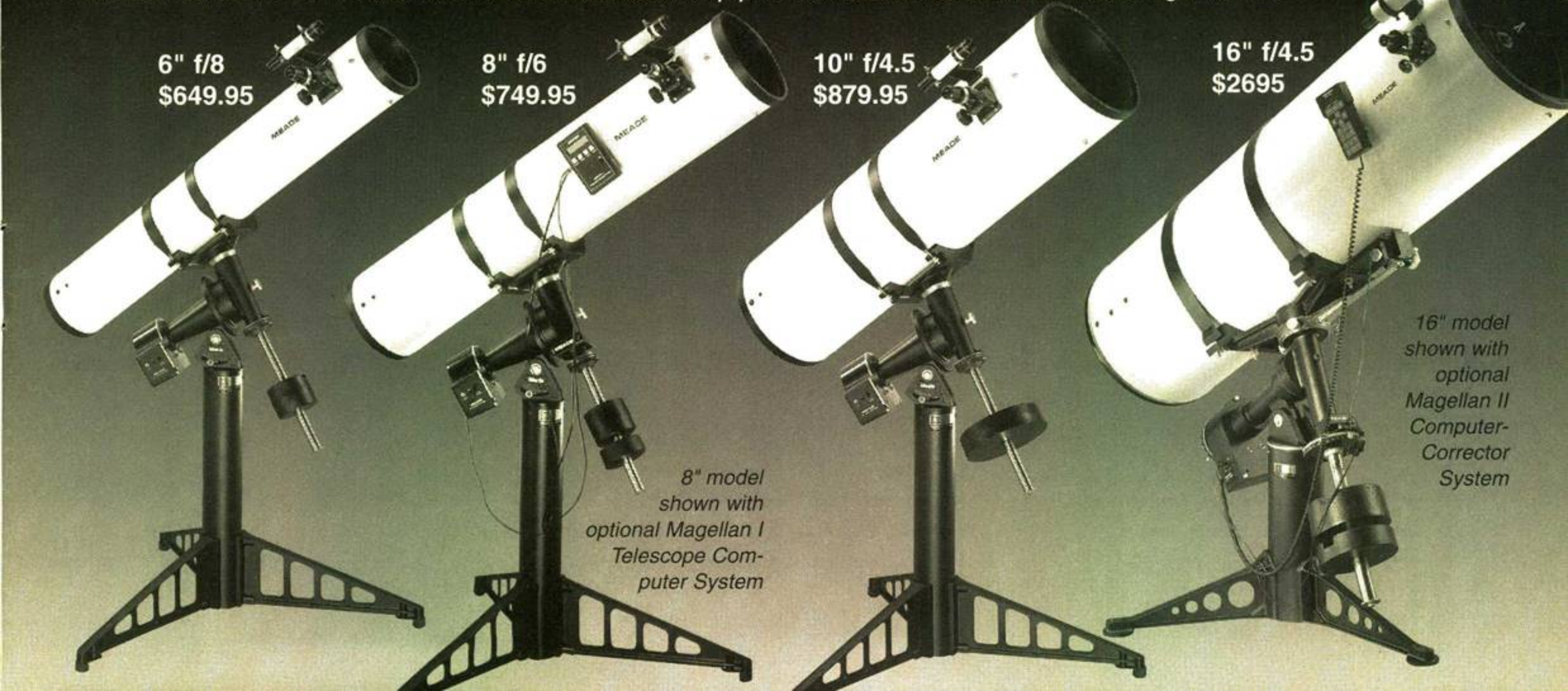
STARFINDER EQUATORIAL TELESCOPES ***Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.***



8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System

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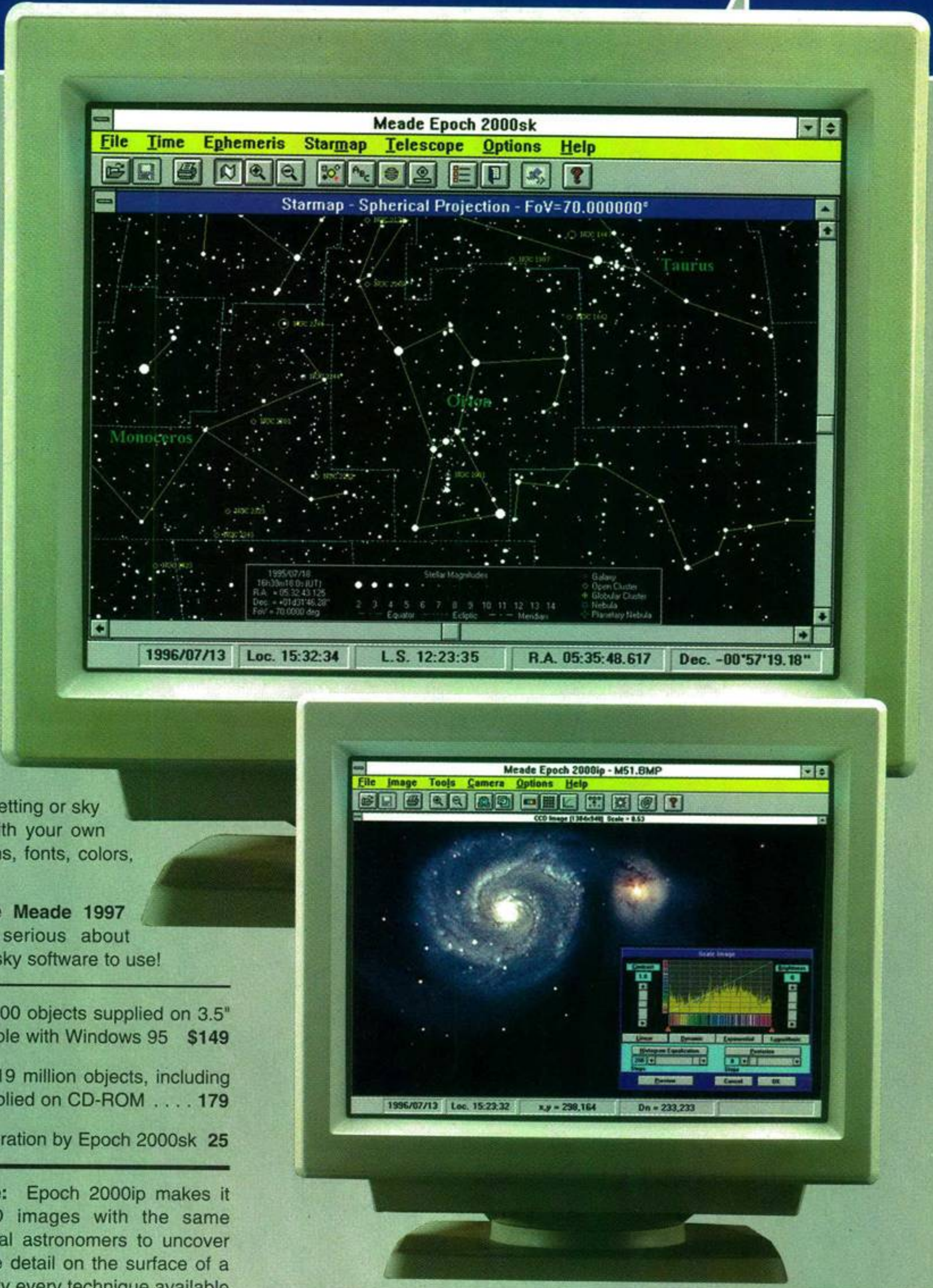
EPOCH 2000® SKY SOFTWARE


Meade Epoch 2000sk
File Time Ephemeris Starmap Telescope Options Help
Starmap - Spherical Projection - FoV=70.000000°
Taurus
Orion
Monoceros
1996/07/13
Loc. 15:32:34
L.S. 12:23:35
R.A. 05:35:48.617
Dec. -00°57'19.18"
Meade Epoch 2000ip - M51.BMP
File Image Tools Camera Options Help
1996/07/13
Loc. 15:23:32
x,y = 298,164
Dn = 233,233

The most powerful astronomical software ever made available can now be yours for only $149!

Now you can use the most advanced, most precise sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** no longer is the Trapezium in Orion, for example, shown as a single point as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Print professsional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

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EPOCH 2000sk Sky Software: 281,000 objects supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 **$149**

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LX200 Interface Cable: for Meade LX200 operation by Epoch 2000sk **25**

Epoch 2000ip Image Processing Software: Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

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EYEPIECES AND ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (3.45)
32mm (52°); **40mm** (44°)	each:	**99.95** (3.79)
56mm (52°; 2")		**199.95** (5.48)

Series 4000™
2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (4.27)

Series 4000™
Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (3.94); **18mm: 149.95** (3.94); **24.5mm: 179.95** (4.68); **32mm** (2"): **239.95** (5.87); **40mm** (2"): **299.95** (6.28)

Series 4000™
Ultra Wide Angle
84° field;
multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (3.94); **6.7mm: 199.95** (3.94); **8.8mm** (1.25"/2"): **239.95** (5.87); **14mm** (1.25"/2"): **299.95** (6.28)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (3.45)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (3.45)

Series 3000™ Plössls
50° field; multi-coated

The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.45)

Series 4000™
f/6.3 Focal Reducer/
Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.29)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (2.98)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (2.98)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (2.98)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.29)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (3.45)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (3.85)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (3.94)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (3.45)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (3.85)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (3.94)

Series 3000™
Plössl
40mm
44°

An excellent complement to the Series 3000 Plössls above, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, **multi-coated.** Barrel dia. 1.25"; threaded for filters. Apparent field: 44°.

$79.95 (3.79)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (3.45)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (3.45)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$99.95** (5.87)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.45)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (4.27)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (3.45)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. 1.25" **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (3.45)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (2.98)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (2.98)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

HOW TO ORDER

- Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes.
- Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price.
- Meade accessories may be ordered from any Meade Advanced Products Dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE CO., Burbank, CA.
Orders & Information: 818-505-8424.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 312-332-2000.

Canada:

EFSTONSCIENCE, Toronto, Ontario.
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KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

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IDENTI-VIEW™
PREMIUM GLASS SOLAR FILTERS
- **SAFE** • **HIGH QUALITY**
- **STRICT CONTROL STANDARDS**
- **LIMITED LIFETIME WARRANTY**

CLASS "A"
Color band - blue. Class "A" filters are made with the same premium quality polished glass and multi-alloy coating as Class "B". An additional steel alloy added to the coating process makes our Class "A" filters extremely scratch and fade resistant. Excellent for visual and photographic use. Light transmission is 1/1000th of 1%.

CLASS "B"
Color band - white. Class "B" filters are made with polished glass and multi-alloy coating. These filters offer great durability and will provide many years of service and enjoyment with normal use. Can be used visually and for photography. Light transmission is 1/1000th of 1%.

CLASS "C"
Color band - red. Class "C: filters are specifically coated to a lighter density (ND-4). They are for photographic use only. This filter is intended for use by professionals and serious hobbyists. Light transmission is 1/100th of 1%.

ORDERING INFORMATION
1. State scope brand and model number, aperture and outside diameter with filter class and price.
2. Make check or money order payable to J.M.B. Inc. All foreign checks must be payable through a U.S. bank.
3. Shipped free within the continental United States. All others add $5.50 Shipping and Handling per filter. Michigan residents add 6% sales tax. Allow 2-3 weeks for delivery.

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301-972-8040

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ASTRO LETTERS

NASA

Not only was the HST servicing mission textbook perfect, it also included an unscheduled spacewalk to fix the telescope's thermal blanket worn out during its seven years of exposure to space.

Bring Hubble Home

The Hubble Space Telescope has become a household name synonymous with discovery and has stirred the imaginations of millions with amazing views of the universe ("Towards a New Hubble," February 1997). It will go down in the annals of astronomy as an important and revolutionary scientific instrument alongside Galileo's telescopes, which are preserved to be marveled at by future generations. After its mission is complete, the HST should be returned to Earth so that an important piece of history is not lost forever. — *Rod Norman, Mt. Pearl, Canada*

Just Look Up!

I enjoyed "Earth, Wind, Fire, and Stars" (March 1997). My urban New York childhood was thankfully interrupted by magical weekends spent at our great-grandparents summer home in the Catskill Mountains.

At night, I would crawl into my sleeping bag lying on the picnic table, and gaze at the snowy road of the Milky Way.

I now live in rural Pennsylvania. The lure of the heavens is stronger than ever, and to learn the constellations I picked the easiest, most nontechnical book I could find, *The Stars*, by H. A. Rey. I also learn more with each issue I read of ASTRONOMY.

While I save money for a telescope, I'm using a pair of 10x50 binoculars. My enthusiasm must be infectious. In the last year, I've shared planets, constellations, two comets, and an eclipse with my friends and husband. They now ask for stargazing sessions.

I turn people on to astronomy by emphasizing they do not need to be rocket scientists to enjoy the stars. Anyone can participate by simply going outside on a clear night and looking up. When I read your magazine at work, my co-workers frequently point at pictures and say, "Wow! What's that?" — *Dawn Sanguedolce-Moyer, Unityville, Pennsylvania*

Build Memories That Last a Lifetime

While reading Bob Hillery's letter (March 1997) about his observing sessions with his six-year-old Katie, I was reminded of the "awesome" comments from our older grandchildren last summer. They saw the Milky Way for the first time while we were camping and canoeing north of Lake Superior in Ontario. Each night I took them out on the lake in the canoe. They sky was black and star-studded with the magnificence of the heavens. The stars and our nearby campfire were the only lights we could see.

Mr. Hillery is building memories and beauty that will last Katie a lifetime. — *John Deering, Highland Heights, Kentucky*

Satisfied Deep-Sky Observer

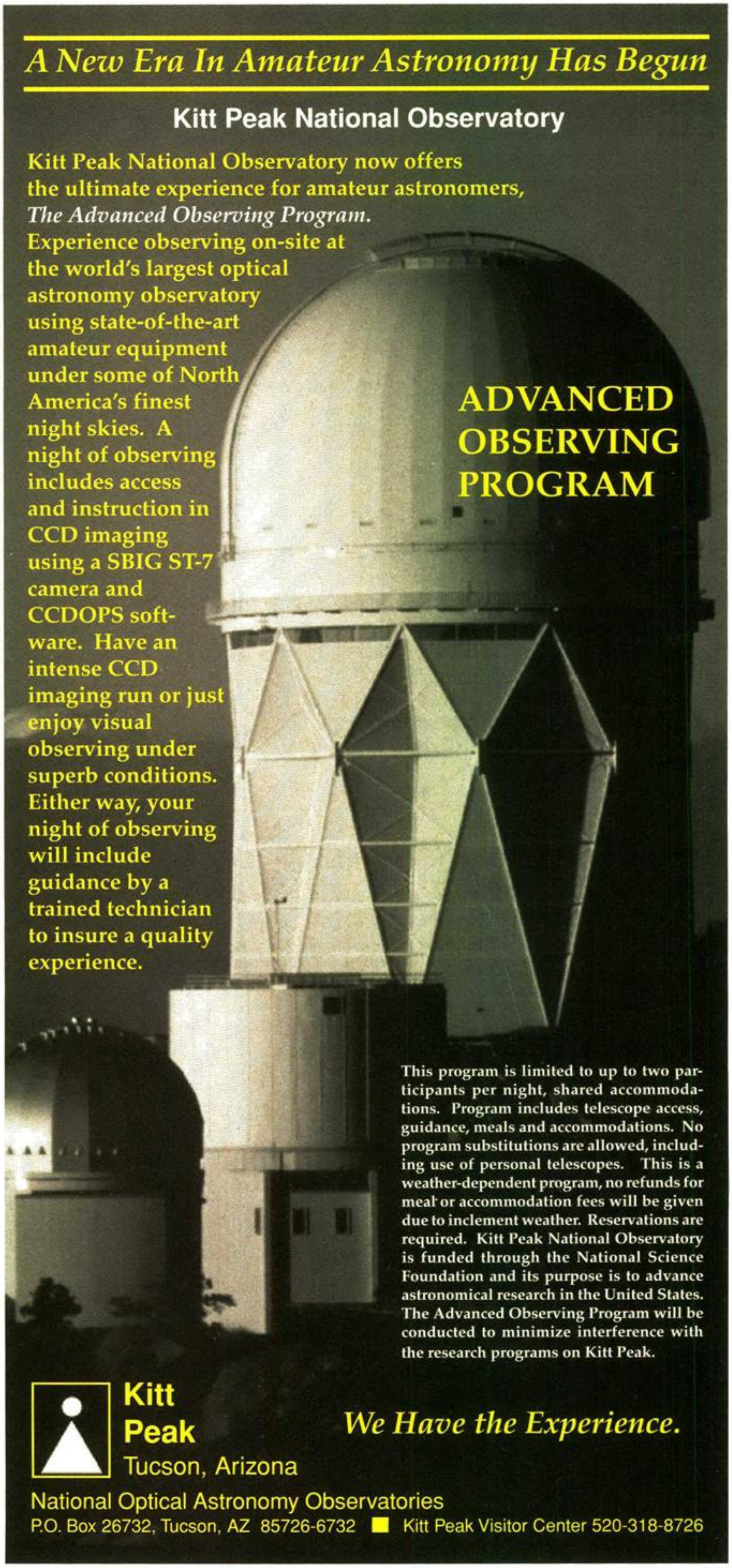
I appreciate the deep-sky articles that appeared lately ("Faint Balls of Fire," September 1996 and "Observing Hickson Galaxy Groups," December 1996). While they may not be immediately relevant to small-scope owners, they can whet appetites for more aperture sometime in the future, and the needs of large-scope owners are being met.

Additionally, Mark Coco described *Uranometria* as the best ninth magnitude star atlas in his final article ("Star Maps Are a Gazer's Best Friend," December 1996).

I doubt he had access to the Herald-Bobroff *AstroAtlas* ("New Products," February 1997) which has limited distribution in the United States. Here in Australia, there is much debate as to which of these two is the better atlas.

Some people think that the *AstroAtlas* is too cluttered and don't like the depictions of nebulae. Others think that it has superior maps of the Virgo-Coma region and the Magellanic Clouds. I think both atlases are great, and a deep-sky aficionado will probably want to own one of each.

On a different subject, I purchased a 14.5-inch Compact Starsplitter telescope based on John Shibley's "The Starsplitter Compact" review (May 1996). I've had no difficulty assem-



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bling it in the field and I am totally satisfied. — *Renato Alessio, Keysborough, Victoria, Australia*

Freedom Scrutinized in Cosmological Constant

I enjoyed Ken Croswell's "Playing Cosmology's Wild Card" (April 1997), but am intrigued by one sentence that referred to the age of the universe. Croswell wrote, "Of course, it's just this great freedom that causes scientists to distrust the cosmological constant, for like a wild card its numerical value seems to be anything the player wants."

There emerges an interesting dichotomy of thought among scientists regarding when to plug in a mathematical ploy. Particle physicists apparently have no problem applying the "renormalization" procedure to the puzzle of resolving infinities that clutter up quantum field theory, but renormalization is nothing more than a mathematical trick for validating an answer you have already predetermined.

If cosmologists have difficulty with pulling a value for the cosmological constant out of the blue, all they need to do is set an age for the oldest stars based on the best empirical evidence. Then they can set the cosmological constant at a value that will yield an age for the universe just great enough to encompass the age of the oldest stars, then proceed from there.

As we penetrate further back into the emerging universe with new observational evidence, the future value of the constant can be fine-tuned to fit each new layer of data that is collected. This will keep the picture of an expanding universe consistent with the known data until some future time when the actual value of the constant is determined by the scientific method. — *Thomas McCartney, Auburn, New York* □

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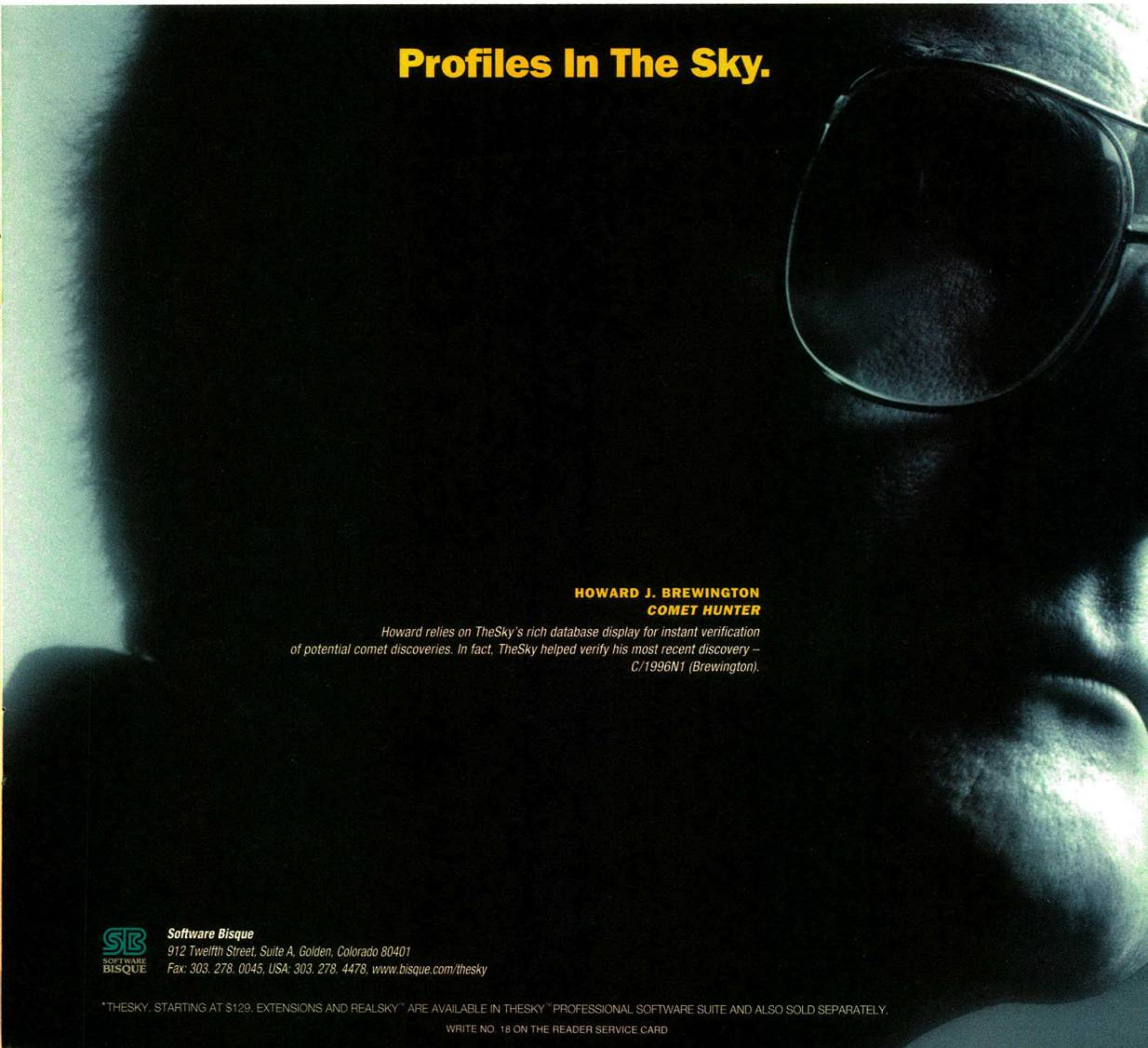
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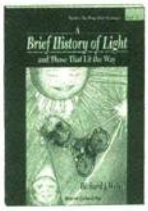
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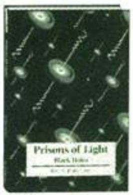
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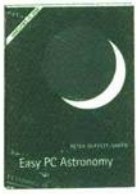
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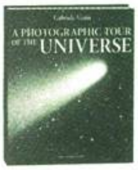
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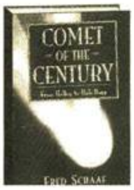
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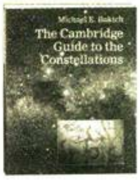
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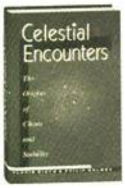
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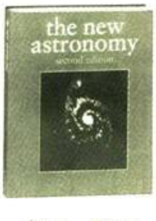
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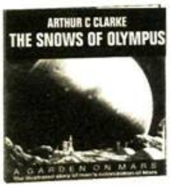
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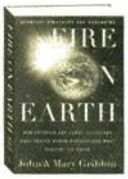
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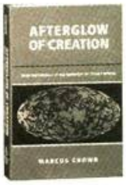
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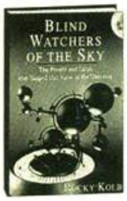
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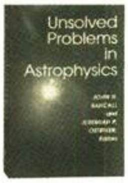
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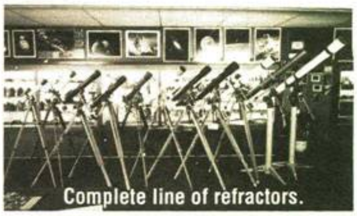

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ASTRO FORUM

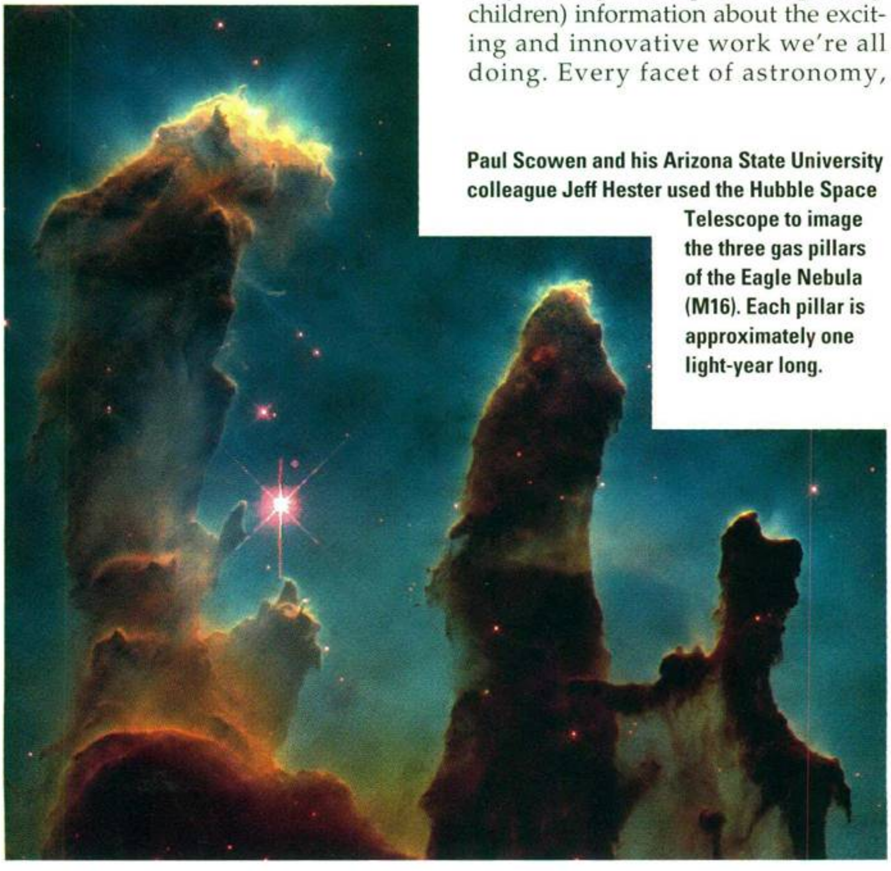
Give the People What They Want

by Paul Scowen

Over the past five years I have had the pleasure and privilege of being closely associated with the Hubble Space Telescope. It is a continual source of excitement and wonder to see the many new results coming from Hubble in the years since the first servicing mission. After that mission, NASA impressed upon all players the need to reach out and communicate to the public what was going on with and being learned from Hubble. Though originally motivated by the need to explain why NASA mounted such a costly servicing mission, this is still a worthy goal.

The current federal funding climate is spartan. Congressional representatives are faced with tough decisions over which programs to fund and which to cut. In this climate, it is crucial that professional astronomers, and also amateurs, conduct a vigorous campaign of public talks and outreach. Increasing public awareness of modern astronomy can only serve to improve the grassroots support for federal funding of expensive projects such as the Hubble Space Telescope.

I have been lucky enough to have been part of several high-profile Hubble programs over the past two to three years. This involvement has provided me with numerous opportunities and invitations to give talks all over the country. I have pursued these invitations with great enthusiasm because I actually enjoy giving public talks. They always generate much more excitement than you might typically see at talks at, say, American Astronomical Society meetings. We have, as astronomers, a duty to relay to the public (especially children) information about the exciting and innovative work we're all doing. Every facet of astronomy,



Paul Scowen and his Arizona State University colleague Jeff Hester used the Hubble Space Telescope to image the three gas pillars of the Eagle Nebula (M16). Each pillar is approximately one light-year long.

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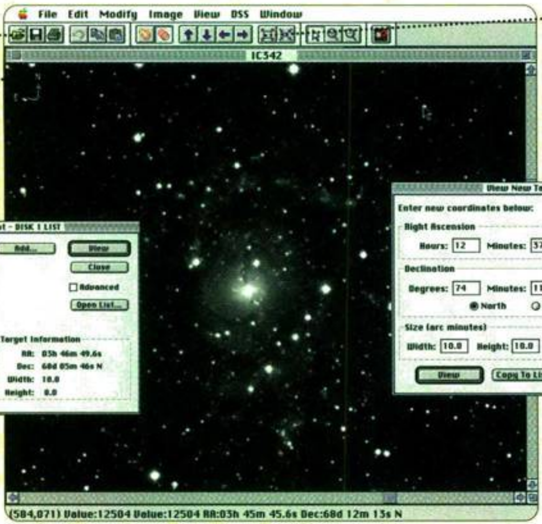

Name:
NGC6503
NGC6654
NGC6643
UGC10803
NGC6540
NGC4127
NGC4133
IC342
NGC 7762
NGC6015
NGC5322
NGC5204
NGC4605
NGC4125
NGC4236

☐ Advanced

Target Information
RA: 03h 46m 49.6s
Dec: 68d 05m 46s N
Width: 10.0
Height: 0.0

Enter new coordinates below:
Right Ascension
Hours: 12 Minutes: 37 Seconds: 25.5s
Declination
Degrees: 74 Minutes: 11 Seconds: 41.s
● North ○ South
Size (arc minutes)
Width: 10.0 Height: 10.0
Epoch
2000.0

(584,071) Value:12504 Value:12504 RA:03h 45m 45.6s Dec:68d 12m 13s N

Print RealSky finding charts

Zoom in on any area

Use North/East indicators to orient yourself

Enter RA and Dec for the field you wish to view

Select well-known objects-including all NGC objects-from included target lists

Alter field of view from 5 to 60 arcminutes

Use status bar to show RA and Dec with a click of your mouse

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Astronomical Society of the Pacific

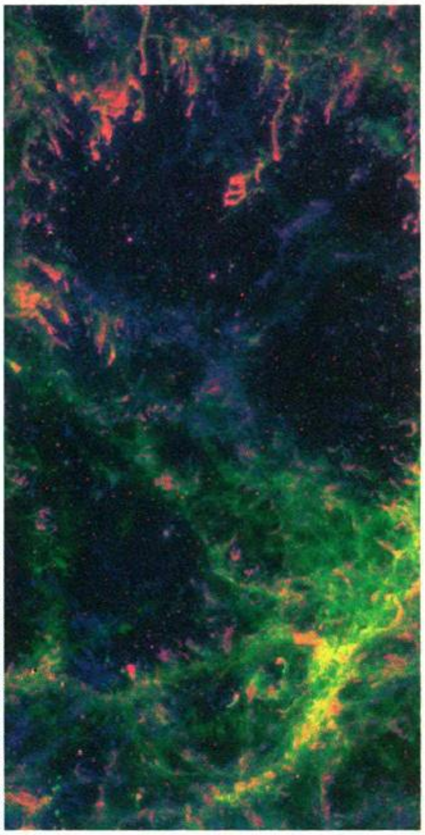
WRITE NO. 73 ON THE READER SERVICE CARD

when presented correctly, will elicit plenty of ooh's and aah's from a fourth-grade classroom. I strongly urge the community to do more to this end. But the showing so far has been poor.

Many researchers reading this might say, "I'm already too busy, and behind on several projects, I don't have time for this Mickey Mouse stuff." I've heard this refrain many times before, from young astronomers as well as old. But we need to set aside time for outreach just like we do for any other aspect of the world of modern astronomical research, such as teaching, writing grant proposals, attending conferences, and writing papers for scientific journals. Communicating the exciting things we're learning from the Hubble Space Telescope pays dividends that cannot be immediately seen or assessed. The enrichment of society around us, if only accomplished one small step at a time, is a noble and admirable cause for all of us to follow.

We need to give feedback to the general public for another reason: they've earned it. After all, it's public money that pays for Hubble. The public should get the bang for the buck that they invested in this program. To date, the Space Telescope has cost Americans two or three dollars per man, woman, and child, so we have a debt to pay there. Those of us who use the telescope are beholden to the press, the public, and the world in general to feed back what we've been learning. We need to educate humanity, not just our professional colleagues.

People who work in the media keep going back to the same group of astronomers — those who take the time to clearly explain their work. We all need to do a better job of this. Unfortunately, not all of us are the most expressive, or relish the thought of standing up in front of 400 people to give a public talk. But those of us who can should reach out to the public around us and tell everyone what neat stuff we're doing. With the explosion of the information age, it has become much easier to communicate



J. Hester and P. Scowen (ASU) and NASA

Scowen and Hester imaged filaments in the Crab Nebula (M1) with Hubble.

with a large number of people in the public, whether by the conventional media (such as this magazine) or by newer methods such as the World Wide Web.

I was motivated to write this article by conversations with several people in the media, as well as by feedback I have received from members of the public at talks I have given. I do not intend to be too preachy, and I apologize if I have come across that way. I would just like to encourage those of you who have neat stuff and who don't already do some public outreach to get out there and show the public why you're excited about what you do.

Arizona State University astronomer Paul Scowen has been at the forefront of research with the Hubble Space Telescope. He has recently branched out into astronomical multimedia design for education.

APM - Markus Ludes

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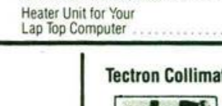

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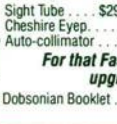

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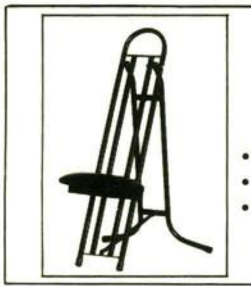

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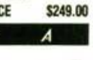

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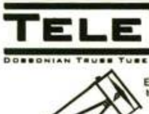

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Toward a Bigger, Older Universe

The first results from the European Space Agency's Hipparcos satellite suggest the universe is some 10 percent larger and older than previously thought. The findings could go a long way toward resolving the disquieting observations that until now seemed to make the universe younger than its oldest stars.

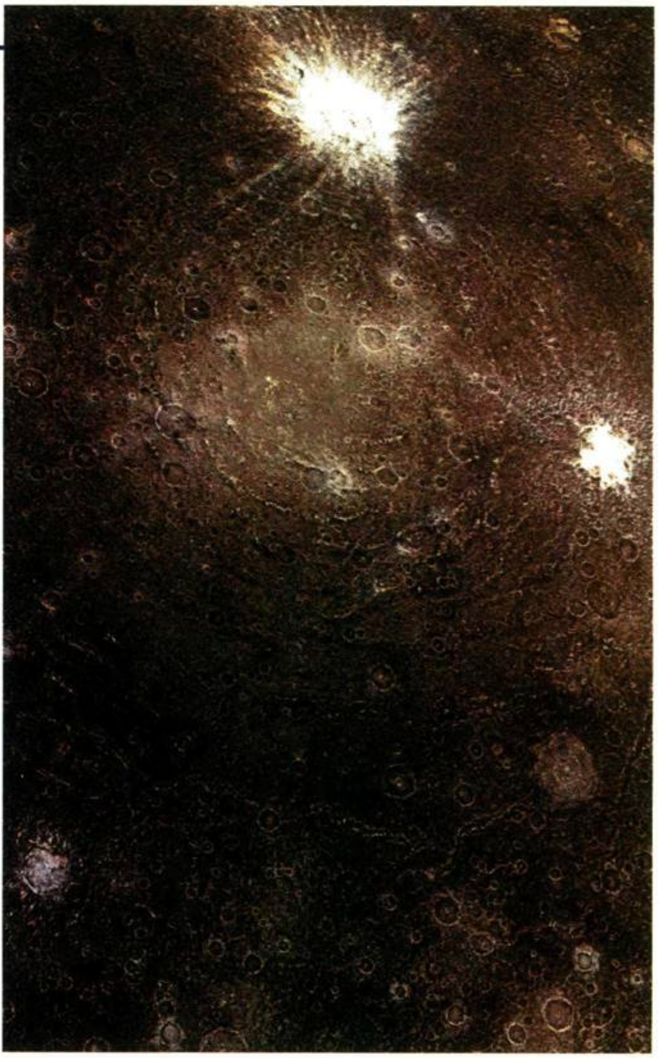
Launched in August 1989, Hipparcos measured precise positions and motions for 120,000 stars and logged an additional million stars with somewhat less accuracy. By observing the slight change in the position of relatively nearby stars in response to Earth's orbital motion around the sun, called parallax, Hipparcos was able to pin down stellar distances 100 times better than previous studies. This observational feat is equivalent to using a telescope in Los Angeles to pinpoint the position of a quarter in New York City.

Michael Feast of the University of Cape Town in South Africa and Robin Catchpole of the Royal Greenwich Observatory in Cambridge, England, used Hipparcos to measure the distances to 26 Cepheid variable stars. Cepheids provide a powerful yardstick for measuring distances in the cosmos because they vary with periods proportional to their luminosity. Observe a Cepheid's period and you know how much light it gives off, compare that with how much light you receive and you have its distance.

The Hipparcos results place Cepheids about 10 percent farther away than previously thought. The finding has a ripple effect, however, because astronomers use these stars to measure distances to other galaxies, which are used in turn to measure even greater distances. Thus the new findings effectively increase the size of the entire universe by 10 percent. That also reduces by 10 percent the rate at which the universe is expanding — the Hubble constant — and adds about a billion years to the universe's age, making it 10 to 13 billion years old.

Feast and Catchpole fed their results into calculations for the age of globular clusters, spherical collections of up to a million stars that contain the oldest stars in the universe. They conclude that the clusters are a few billion years younger than previously thought. If the results stand the test of astronomers' scrutiny, this would make the stars in globulars only about 11 billion years old, finally bringing them within the range of estimates for the universe's age.

Galileo's Journey Continues


NASA/JPL

The multi-ring basin Asgard dominates this part of Callisto's leading hemisphere, which spans almost 860 miles (1,400 kilometers). Centered on the smooth, bright region near the middle of the image, Asgard is surrounded by concentric rings that span approximately 1,050 miles (1,700 km). Bright, icy material emanates from the more recent crater Burr (above Asgard), contrasting sharply with the darker, slightly reddish coatings on older surfaces.

When Jupiter passed behind the sun last January, the Galileo spacecraft remained out of communications range from Earth for nearly three weeks. And with no flybys of Jupiter's Galilean moons between mid-December and mid-February, researchers had a golden opportunity to more closely analyze observations from earlier flybys.

One surprise planetary scientists are still trying to puzzle out is the paucity of small craters on Callisto, the most heavily cratered object in the solar system. Based on Voyager images, researchers expected to see craters down to the limit of Galileo's resolution, but instead face a landscape curiously lacking in the smallest craters. Scientists think the small craters may have been softened or modified by debris moving downslope and revealing ice-rich surfaces. A global view taken by the Near Infrared Mapping Spectrometer also shows that the area surrounding the multi-ring basin Asgard contains significant amounts of exposed water ice compared with the rest of the moon's mineral-rich surface.

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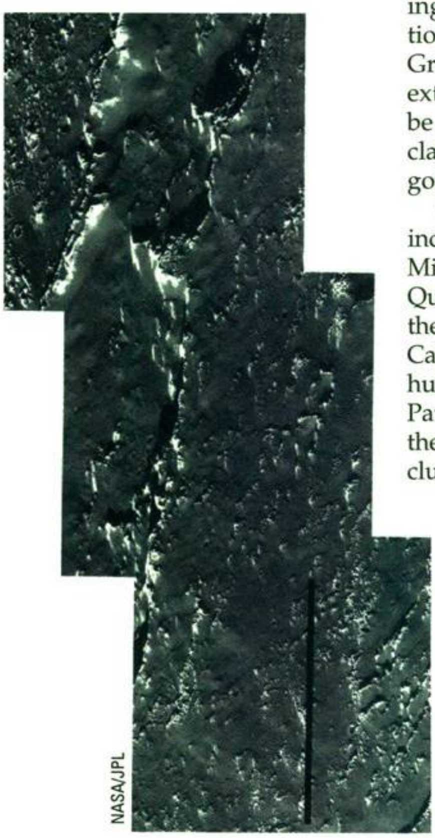
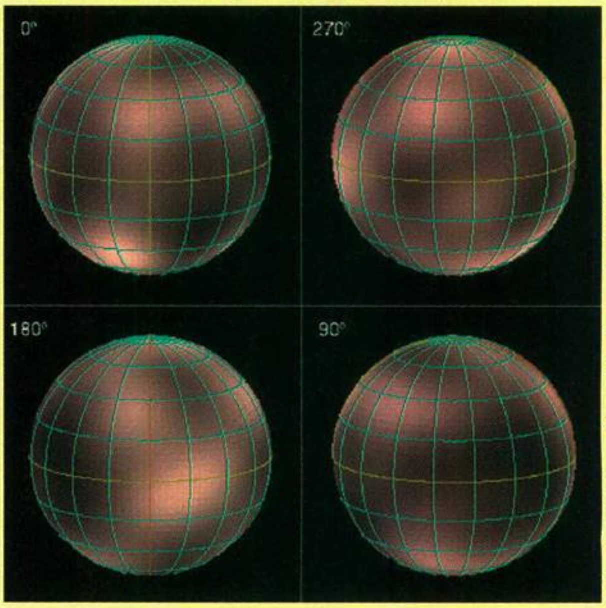
Following Jupiter's conjunction with the sun, the spacecraft next targeted icy Europa for a return visit on February 20. The spacecraft performed flawlessly as it flew past at an altitude of 360 miles (580 km), its closest approach to the moon during the two-year nominal mission. Observations concentrated on different regions of the moon under different sun angles than the first flyby. Those observations were being radioed to Earth as this issue of ASTRONOMY went to press.


NASA/JPL

A three-image mosaic of the northern part of the Valhalla region of Callisto covers an area 28 miles (45 kilometers) across and includes part of a crater chain running down and slightly to the left from the top of the image. Planetary scientists think the chain formed when a fragmented projectile, perhaps similar to Comet Shoemaker-Levy 9, smashed into the surface.

Hubble Maps Pluto



S. Alan Stern (Southwest Research Institute), et al. and NASA

Astronomers have obtained their highest resolution maps yet of Pluto's surface, thanks to the Hubble Space Telescope. Surprisingly, the Hubble images reveal that this diminutive world shows more regions of high and low contrast than any planet or moon in the solar system. "This means Pluto would be very interesting to see at higher resolution," says planetary astronomer Alan Stern of the Southwest Research Institute. "Most planetary bodies are highly muted so scientists often boost the image contrast to make features more easily discernible, but Pluto is a visual boomer." The images also show that Pluto has large, bright polar regions and may possess linear features stretching hundreds of miles.

Is the 51 Pegasi Planet Dead?

Is there a planet orbiting the star 51 Pegasi? Recent observations of 51 Pegasi by astronomer David Gray of the University of Western Ontario have raised a firestorm of controversy. "I'm not calling the planet into question, it doesn't exist," says Gray. "The evidence is extremely strong. It would be plain foolhardy to claim at this point that it's got a planet."

But a group that includes Swiss astronomers Michel Mayor and Didier Queloz, who discovered the purported planet, and California-based planet hunters Geoff Marcy and Paul Butler responded on the Internet that "the conclusion claimed by David Gray is extraordinarily premature."

Mayor and Queloz discovered the planet by observing how the star's spectral lines alternately shift from the red to the blue and then back to the red over a 4.23-day period, as if the star were being pulled back and forth by an unseen orbiting companion. Gray attributes these periodic shifts to pulsations in the star's atmosphere rather than wobbles induced by a planet. In a paper published in the February 27, 1997, *Nature*, Gray reports seeing changes in the shape and depth of the star's spectral lines that both vary with the same 4.23-day period. "The simple fact is that a planet tugging on the central star can only shift the spectral lines, it cannot change their shape," says Gray. Because the three periods are the same, he thinks they are all caused by pulsation.

The Swiss and California teams counter that no such pattern of pulsation has ever been observed before in a solar-type star. The sun oscillates, but with periods lasting minutes and hours, not days. In addition, theoretical models had not previously predicted that solar-type stars could pulsate on four-day timescales. The planet proponents further argue that the star would vary in luminosity if it were pulsating, when observations show the star's brightness stays remarkably constant.

Gray's findings also call into question the other so-called "hot Jupiters" — massive planets located so close to their host stars that they complete an orbit in just a few days. Although he has yet to observe Rho^1 Cancri, Tau Bootis, or Upsilon Andromedae, Gray believes similar stellar pulsations could explain the planets claimed to be orbiting those stars. His work does not, however, cast doubt on any of the other 10 or so extrasolar planets discovered to date.

So whom should one believe? "I think the truth might very well be some-

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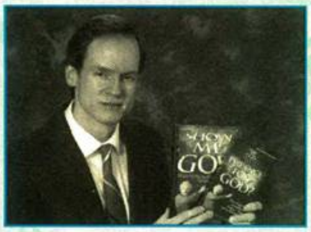

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where in between. If you ask five astronomers you'll get seven opinions," says University of Texas astronomer William Cochran. Several astronomers, including Cochran, have suggested that the planet, because it is so massive and close to the star, could be raising tides in the atmosphere of 51 Peg. The shifting lines seen by the Swiss astronomers represent the planet's orbital motion, while the changing line shapes and depths seen by Gray represent tidal bulges appearing and disappearing as the planet goes around the star. Says Gray of this idea: "That's just grasping at straws."

End of the Road for Pioneer 10

This past March, one of the Space Age's greatest and hardiest heroes, the Pioneer 10 spacecraft, went gently into that good night. Pioneer 10 — the first spacecraft to cross the asteroid belt, examine Jupiter up close, and leave the solar system — had become too feeble to do important science.

"NASA operated the Pioneer mission as long as it had enough power to return science data about the conditions in space as far from Earth as possible," says Wesley T. Huntress, Jr., Associate Administrator for Space Science at NASA Headquarters in Washington, D.C. "We ended the science mission in late March because the power had finally become too weak to do significant science."

The end came just a month after Pioneer 10 celebrated its 25th anniversary of operation. Launched on March 2, 1972, on what was planned as a two-year mission to Jupiter, the craft shattered expectations. It blazed a trail through the asteroid belt, the region between Mars and Jupiter populated by innumerable rocks of all sizes. Before Pioneer, no one knew if a spacecraft could survive the passage through this shooting gallery. Pioneer showed it could, paving the way for its sister craft, Pioneer 11, as well as Voyagers 1 and 2 and Galileo.

When Pioneer 10 flew past Jupiter in December 1973, it took detailed measurements of the giant planet's atmosphere, interior, radiation belts, magnetic field, and magnetosphere, all for the first time. And it determined the exact masses of the planet and its four large Galilean satellites: Io, Europa, Ganymede, and Callisto.

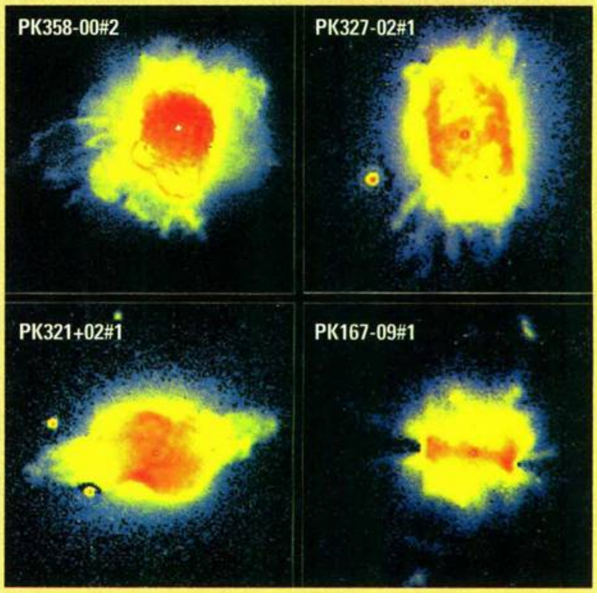
In 1983, Pioneer passed beyond the outermost planets, Neptune and Pluto. Today it lies over 6 billion miles away and its radio signals take more than nine hours to reach Earth. Traveling at 28,000 miles per hour, the spacecraft continued relaying information about the extent of the sun's influence and searched for the boundary where the solar wind bumps into the interstellar medium.

But the spacecraft's 8-watt signal (equal to the power of a night light) reaches Earth with a strength of just 0.3 billionths of a trillionth of a watt. It was the weak signal that caused NASA to end the mission. Now the gritty pioneer will continue cruising, silently bearing witness to happenings in the vast expanses between the stars.

NASA

The first close-up views of Jupiter came to us through the 11 instruments on Pioneer 10. After 25 years in space, the spacecraft no longer has the power to do significant science, and NASA has decided to end its mission.

Hubble Examines the Planetary Nebula-Planet Connection



Raghvendra Sahai and John Trauger (Jet Propulsion Laboratory) and NASA

Using the Hubble Space Telescope, astronomers Raghvendra Sahai and John Trauger of NASA's Jet Propulsion Laboratory were able to image detailed structure in four planetary nebulae that are so young we're seeing them in the early stages of formation. Planetary nebulae were named due to their eerie resemblance to planetary disks, but in actuality they are the gaseous shrouds of dying stars. These 2,000- to 4,000-year-old nebulae show up as indistinct blobs in ground-based images. The nebulae have a bewildering variety of shapes, but the stars that form them are uniformly round. Sahai and Trauger think multiple jets of high-speed gas are turning on and off in various directions, sculpting these complex features. The jets themselves are triggered by companion objects. Due to the variety of complex shapes, the researchers suggest that many of these companions are substellar, either brown dwarfs or planets. "The name planetary nebula maybe isn't such a misnomer after all," says Sahai. "Maybe there is a deep connection with planets that we hadn't realized."

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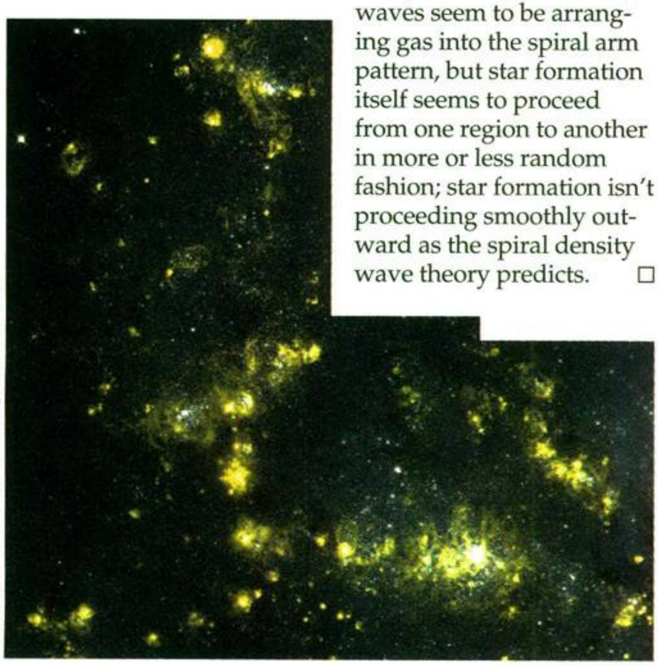
Star Formation in M101

M101 is a stately spiral galaxy 24 million light-years from Earth. The galaxy is slightly larger than the Milky Way, but is otherwise quite similar except for one thing: it is undergoing extremely violent star formation in several places. A team of astronomers led by Paul Scowen of Arizona State University has aimed the Hubble Space Telescope at M101 to find out what sorts of mechanisms trigger this intense star formation.

Two theories have been developed to explain star formation in spiral galaxies. One theory says that spiral density waves roll through the galaxy, piling up gas into large clouds that define a galaxy's spiral arms. The spiral density waves also trigger the collapse of gas clouds, leading to rapid star formation. The other theory states that star formation is essentially random and self-propagating. In this scenario, stars form in one region, the most massive ones quickly go supernova, and pressure waves from the supernovae ignite star formation in surrounding regions.

"Of course reality is somewhere in between," says Scowen. "What we see in M101 are both processes working in harmony." The spiral density waves seem to be arranging gas into the spiral arm pattern, but star formation itself seems to proceed from one region to another in more or less random fashion; star formation isn't proceeding smoothly outward as the spiral density wave theory predicts. ☐



Paul Scowen (Arizona State University), et al. and NASA

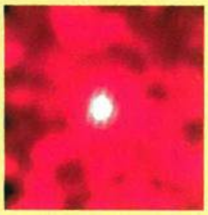
The brightest patches in this Hubble image indicate gigantic regions of star formation in M101 that dwarf the largest such regions in the Milky Way. Massive young stars light up these regions. Filamentary structures indicate places where star formation has mostly petered out as massive stars have exploded and blown away remnants of their stellar nurseries. In other regions, star clusters are easily visible but with no surrounding nebulosity; these are places where star formation has come to an end. Astronomers use this information to track the propagation of star formation in M101.

Largest Supercluster Found

A team of astronomers from the University of Maine and Meudon Observatory in France has discovered a supercluster of galaxies that appears to be the longest single structure yet seen in the universe. The supercluster consists of a string of 23 clusters about 1 billion light-years long that lies 1 billion to 2 billion light-years from Earth. Far too large to be held together by gravity, the supercluster likely formed from perturbations present during the Big Bang, the researchers suggest.

The Moon in Gamma Rays

What would you think if you looked up and saw the moon brighter than the sun? That's exactly what happens when the Compton Gamma-Ray Observatory views the sky. Except during giant solar flares, the sun emits so few gamma rays that Compton can't even see it. But high-energy cosmic rays constantly bombard the moon, creating gamma rays. Ironically, it is only in this high-energy part of the spectrum that the cold, dead moon appears brighter than the fiery sun.



NASA

The moon glows brighter than the sun in gamma rays.

Solar Maximum Headed Down?

Many solar physicists think the upcoming solar cycle will be a strong one, with enhanced sunspot numbers and other magnetic activity on the sun. Using models of how magnetic fields are generated in the sun, however, Ken Schatten of NASA's Goddard Space Flight Center and Sabatino Sofia of Yale University predict a weaker-than-expected solar maximum. They expect the sunspot number to peak at about 130 early in the year 2000, which would reverse a general rise in activity seen during the last 400 years.

A Radio Telescope Larger than Earth

Astronomers are always looking for the sharpest views of celestial objects. Now radio astronomers have gone beyond Earth in their quest for greater resolution. On February 12, the Japanese launched the Highly Advanced Laboratory for Communications and Astronomy, or HALCA, an orbiting telescope 8 meters (26 feet) in diameter. When electronically linked to ground-based radio telescopes, it will triple the resolution of any existing radio array. Astronomers plan to use the new array to peer deep into regions of star formation and into the "engines" that power quasars and active galaxies.

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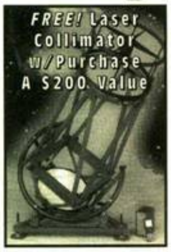

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ENCHANTED CITY

An international community of astronomers flourishes on a mountaintop high in the Chilean Andes.

by Jorge Ianiszewski

The passenger van includes two French graduate students, three Chilean optical technicians and me. We start the 150-kilometer (90-mile) journey from La Serena, a lovely colonial-style city near the Pacific.

For the two French would-be astronomers, it is their first trip to the European Southern Observatory (ESO) at La Silla in the midst of the Chilean Andes. The look of surprise never leaves their eyes as the road climbs north to the desert-like Atacama Plateau, leaving the coast and the scarce vegetation behind. "It's this immense landscape with nothing and nobody that astonishes me," says Phillipe, who is obviously used to a crowded, green country.

La Silla, the largest observatory in the entire Southern Hemisphere, sits atop a 7,700-foot mountain. From a distance, the observatory's 14 shiny white domes give it the look of an enchanted city on a mountaintop.

Belgium, France, Germany, the Netherlands, and Sweden founded ESO in 1962. The goal of these nations was to establish European astronomical research in the Southern Hemisphere. Denmark joined the consortium in 1967, and Switzerland and Italy followed in 1982.

This composite image shows La Silla at dawn with the Large Magellanic Cloud overhead.

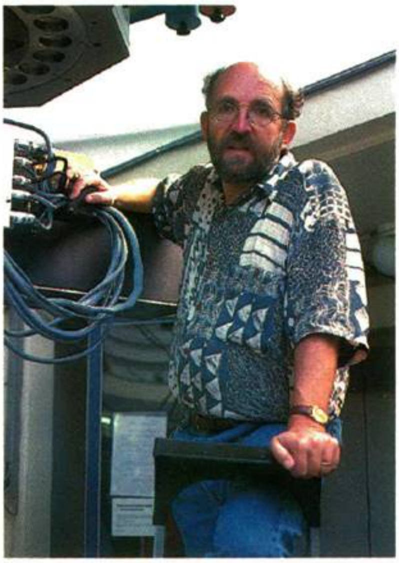
Jorge Ianiszewski / European Southern Observatory

Astronomers chose this particular mountain based on exploration carried out in the Chilean Andes by Dutch-American astronomer Gerard P. Kuiper. Kuiper and German astronomer Jürgen Stock were looking for a place to establish a Southern Hemisphere observatory for the Association of Universities for Research in Astronomy (AURA) after a proposal made in the 1950s by Federico Rutlant, Director of the Observatorio Astronómico Nacional de la Universidad de Chile. With little humidity and air turbulence, seeing conditions in these mountains were remarkable. ESO started to build La Silla in 1965.

We arrive at lunchtime and check in to the very comfortable hotel at La Silla. Food in the dining room is offered cafeteria style; we wait in line with groups of Chilean and European technicians and employees. Some astronomers and students start to show up. For them, this is breakfast — they have just gotten out of bed after a long night of observations.

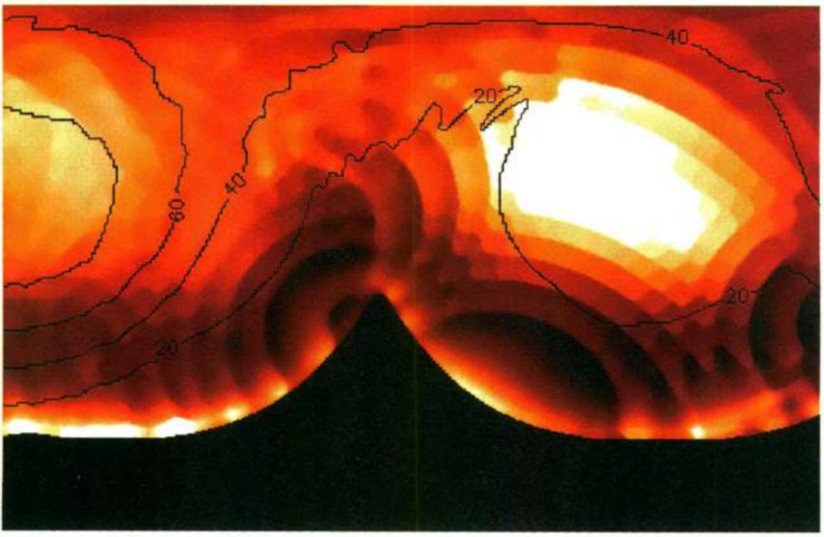
I hear Italian, French, German, and Spanish spoken at the tables, along with English, *lingua franca* at La Silla. There are no English speaking countries in ESO, but to avoid nationalistic jealousies, the consortium chose English as the common language.

Even though you never know who you'll find among the visiting astronomers, I am totally surprised to see Swiss astronomer Michel Mayor sharing his meal with a couple of young students. He is famous worldwide for discovering



Swiss astronomer Michel Mayor at the 1.5-meter Danish Telescope. Mayor discovered the planet orbiting the star 51 Pegasi.

Jorge Ianiszewski



Christophe Dumas/Vesta team

Astronomers using La Silla's 3.6-meter telescope created this image of Vesta's surface. Contours show the distribution of the mineral pyroxene.

the first planet orbiting another solar-type star, 51 Pegasi. But here he is just another worker.

Mayor enjoys talking about his research at La Silla. He is searching for extrasolar planets by studying the spectra of 2,000 apparently single, solar-type stars. He is using the 1.5-meter Danish telescope and the old CORAVEL spectrograph, developed in 1977. This survey provides targets for the much higher precision CORALIE spectrograph being developed at the Observatoire de Genève in Switzerland. CORALIE can detect planets with a much broader range of masses and orbits. It will be mounted on the 1.2-meter Swiss telescope, whose dome is being built at La Silla. One of Mayor's jobs is to oversee construction of this new telescope. It will be used almost entirely to search for extrasolar planets.

The Vesta Team

During another visit to La Silla, I am invited by the young Belgian astronomer Olivier Hainaut, head of the 1994 Vesta Ground Observing Team, to attend its observation run at the 3.6-meter telescope. The team was taking advantage of the Vesta opposition to image the asteroid at near-infrared wavelengths.

I meet the team members at dusk in the computer room, where different groups are at work. Chilean engineers are checking telescope data-gathering software while astronomers are preparing for the night's work.

The Vesta team watches data pop up on their computer screen; left to right: Christophe Dumas, Olivier Hainaut, Hans-Joseph Schöber, and Rudi Albrecht.

Jorge Ianiszewski

Hainaut, a former ESO astronomer, is an asteroid and image processing expert who now works at the University of Hawaii. His computer is connected with one at ESO headquarters in Garching, Germany, 12,000 kilometers (7,500 miles) away. "We sent the images to Garching for processing and deconvolution," he says. "As there is a four hour difference between Germany and Chile, they work while we sleep."

Without moving from Garching or other European institutes, astronomers can perform observations at La Silla, thousands of kilometers away. This has been possible since 1987, thanks to a computer-to-computer connection via satellite. Astronomers have TV images, telephone, e-mail, and telex connection with a Chilean night assistant who is always present in the dome in case of technical failure. Professional astronomers of the future will use remote-controlled telescopes, whether they are ground-based, in orbit, or on the moon.

Hainaut's group is part of an international joint campaign for observing Vesta from space and from the ground. Rudi Albrecht, an Austrian astronomer with the Space Telescope European Coordinating Facility and also part of the Hubble Space Telescope observing team, explains: "Among the asteroids, Vesta occupies a very special position. There is reason to believe that it has best retained its primordial composition." To determine Vesta's surface structure and composition and to confirm its spin axis orientation and rotation period, the Hubble Space Telescope carried out observations in ultraviolet and optical wavelengths. Meanwhile, the 3.6-meter telescope at La Silla observes Vesta in the near-infrared using the Come-On-Plus adaptive optics system, which compensates for atmospheric blurring.

The Vesta team applied for and received eight hours of observing time split over four nights. After

Jorge Ianiszewski

testing and calibrating the instruments on the first night, the team managed to get a few images. As the second night draws closer, we head to the 3.6-meter telescope to prepare the instruments.

The telescope sits at the highest point on the mountain. It looks impressive in its 42-meter-high and 30-meter-wide white metal tower. A thin tower beside it houses the 1.4-meter Coudé Auxiliary Telescope (CAT). The two buildings are connected by a tube.

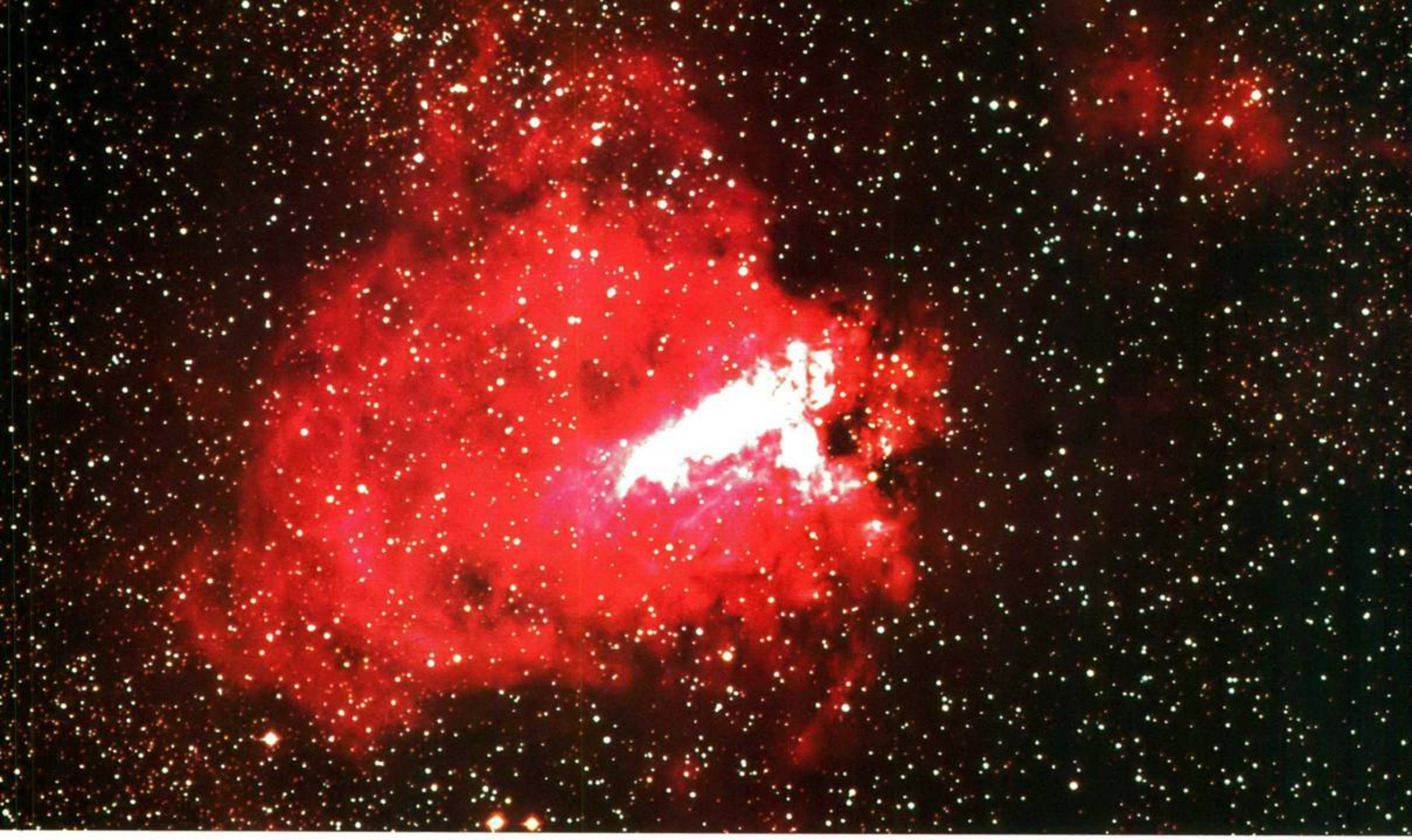
From there, as Earth's rotation hides the sun behind the western horizon, I understand why Europeans selected this isolated place for their Southern Hemisphere observatory. A vast horizon opens in all directions, over an arid land, with the stars crowded all over the night sky. With 80 percent of all nights clear, seeing at La Silla is matched only at the site 600 kilometers (370 miles) to the north at Paranal, Chile, where ESO is building the Very Large Telescope (VLT), and at the Mauna Kea summit in Hawaii.

From a distance, the observatory's shiny domes resemble an enchanted city on a mountaintop.

The 3.6-meter telescope structure welcomes us. In service since 1976, it has a traditional equatorial mount and a 55-cm-thick glass mirror weighing 11 metric tons (12 English tons). This instrument, built for $42 million (U.S. dollars), has long been the mother-ship of the La Silla fleet. ESO has just upgraded it, improving its image quality and making it lighter by removing its heavy mirror system, which allows for better mechanical control. Detectors of the latest generation attach to its Cassegrain cage. It can produce excellent results, such as the astonishing mineralogical map of Vesta's surface, the first such map of an asteroid obtained from the ground.

The 3.6-meter telescope has recently been equipped with the ADONIS adaptive optics system, an upgraded version of Come-On-Plus. ADONIS compensates for atmospheric turbulence through the movements of a deformable reflector and a tip-tilt mir-

La Silla's telescopes are surrounded by a desert landscape.



An ESO telescope images M17, the Omega Nebula in Scutum.

ror inserted in the light path. A computer uses information obtained by a CCD sensor that sees the shape of the distorted light wavefront coming from Vesta. The computer then orders 52 actuators to push or pull a "rubber mirror" 100 times per second to compensate for the light's distortion. This system was developed in a joint effort by ESO and two French laboratories. The VLT will be equipped with an adaptive optics system even more powerful than ADONIS.

An elevator takes us to the building's fifth level, the observation level, which has an oval room that looks like a spacecraft control room. The telescope dome is cooled inside by gigantic air conditioners. "We discovered that air turbulence is generated close to the telescope, mainly by the heat produced inside the dome by humans and equipment," says Albrecht, "so we cool the room before we open the dome until the telescope is at the same temperature as the night environment."

A vast horizon opens in all directions, over an arid land, with the stars crowded all over the night sky.

The Future of La Silla

An hour before the sun dips below the horizon and the air starts to cool, a muffled and joyful sound runs through La Silla. It's the sound of the domes opening so the telescopes can cool to the temperature of the outside environment.

Clouds and excessive humidity can prevent telescopes from opening, but lower budgets for science can also keep telescopes closed. Before ESO started the VLT project, La Silla ruled as the only European observatory in South America. But, as the VLT's four 8.2-meter telescopes are being finished at Paranal, some of ESO's top brass would like to close some of La Silla's instruments.

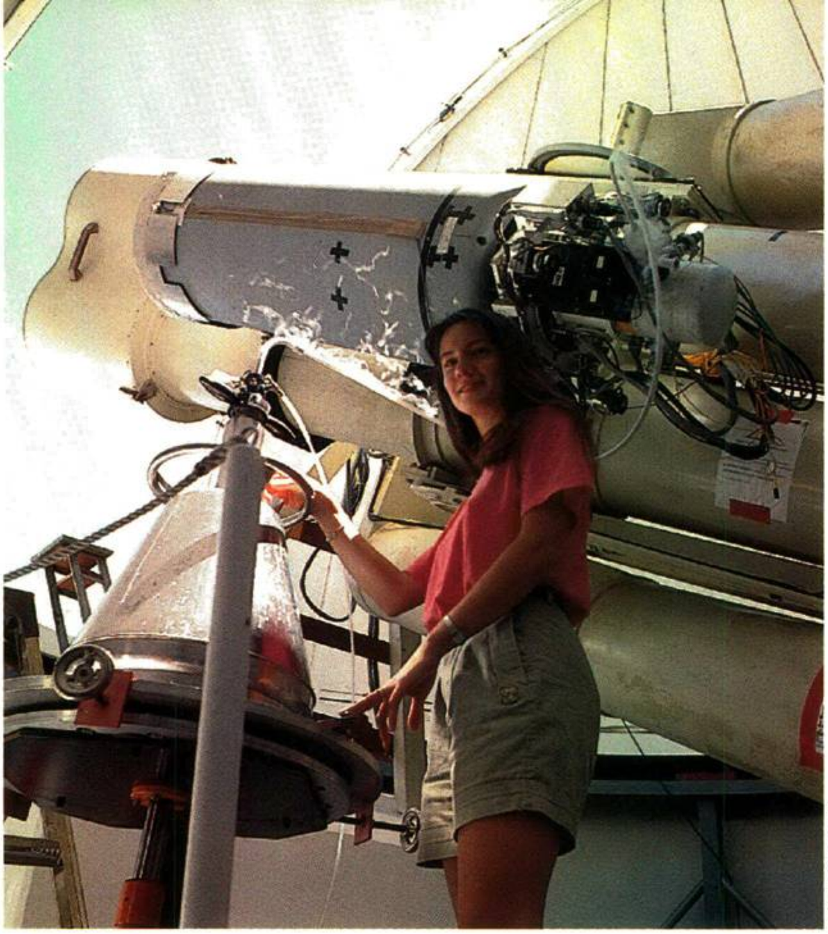
La Silla is an important source for skilled jobs and economic activities in Chile, along with two other observatories in the Chilean Andes, Cerro Tololo and Las Campanas. Anxiety is mounting over La Silla's future. Hundreds of visiting astronomers and technicians pass

European Southern Observatory

through La Silla each year and 140 Chilean employees and technicians work in shifts with 45 international staff members.

But French engineer Daniel Hofstadt, ESO's general manager in Chile, says, "We have no intention of closing La Silla. If you have been there you can see the huge investments we have made. La Silla is going to stay — we have an operational plan until 2003, even beyond." Hofstadt adds that La Silla is the best place for testing new instruments and systems and for training new technicians.

Joint ventures with new institutions and different countries help keep La Silla alive. Brazilian astronomers from the Observatório Nacional are renting 50 percent of the ESO 1.52-meter telescope's time, the French EROS project has installed the 1.0-meter Marly Telescope in a dome formerly occupied by a 40-centimeter telescope, and the Swiss are building a new telescope for Michel Mayor's extrasolar planet search.


Jorge Ianiszewski

French astronomer Nathalie Palanque works for the EROS project, which is trying to identify the nature of the elusive dark matter.

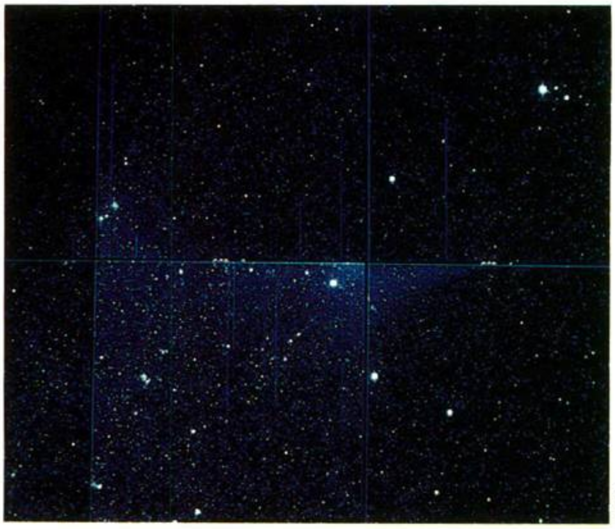
Looking for MACHOs

Meanwhile, life goes on at La Silla. "It's a fairly unusual place," says Nathalie Palanque, a physicist from Saclay, France. Palanque is a member of the predominantly French EROS project, an acronym for Expérience de Recherche d'Objets Sombres (Experimental Searching for Dark Objects).

After a midnight dinner, the EROS astronomers invite me to their telescope. As we walk under the dark night sky, Palanque shares her feelings with us about working at La Silla: "It's so far from everything that stars are almost the only thing one thinks about. The sky here is beautiful. There are no lights around at night except those coming from the stars and sometimes the moon. And in the daytime, I enjoy the changing colors of the mountains."

I ask her about the astronomers' daytime activities. "Well, usually, astronomers and students don't wake up before 2 p.m. They often eat their breakfast at 4 p.m. with the people (technicians, opticians, staff) who work by day and are then enjoying their afternoon snack. It's when the place is most crowded, when everyone is awake. It's also an opportunity to play a volleyball game before dinner."

EROS is a long-term project involving six French astrophysics institutes. Currently in the EROS II phase, the astronomers are looking for dark matter, material that appears to make up roughly 90 percent of the universe's mass yet does not emit light. Specifically, they are looking for dark matter in the form of MACHOs (MAssive Compact Halo Objects), planet- or stellar-mass objects that reside in the halo of the Milky Way Galaxy. EROS searches for MACHOs by observing their microlensing effect on stars from densely populated areas of our galaxy's bulge and both Magellanic Clouds, which are satellite galaxies of the Milky Way. A microlensing event occurs when a MACHO passes


EROS

EROS astronomers took this CCD mosaic of the Large Magellanic Cloud. EROS is looking for dark matter in the Milky Way's halo.

It's so far from everything that stars are almost the only thing one thinks about.

near the line of sight to a background star. The MACHO's gravity focuses the light from the star, so the observer sees the background star brighten.

EROS uses the Marly Telescope and two mosaics each built with eight CCDs. "The volume of data is about eight gigabytes per night," says Cécile Loup from the Institut d'Astrophysique de Paris. "The number of expected microlensing events is about 100 per year towards the galactic bulge and a few per year toward the Magellanic Clouds."

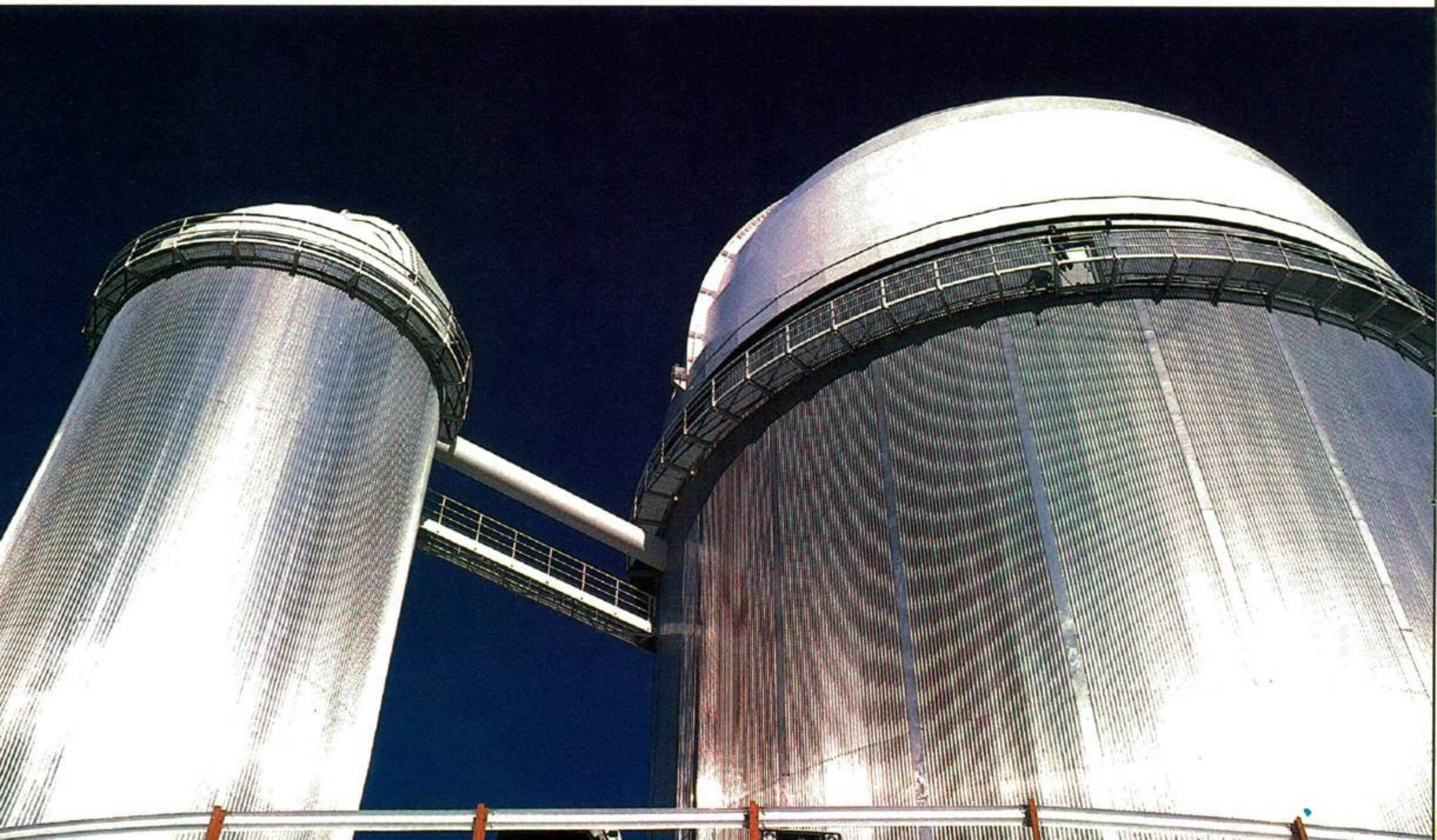
The EROS I project, which began in 1990, found at most only two microlensing events of possible MACHO origin in five years of observations. This was much below the number expected, implying that most of the dark matter is made of something other than MACHOs. But for further conclusions, it will be necessary to wait four or five years until all the EROS II data is analyzed.

It's time to let the astronomers work. I drive around the silent domes with only the parking lights turned on because they need to keep human light pollution at a minimum. Dawn is announced over the mountains to the east by brilliant Venus.

The New Technology Telescope

ESO scientists have the best equipment they can get, including 11 different kinds of CCD cameras, photometers, bolometers, detectors, filters, photographic plates, spectrometers, and correction software for visible and infrared observations. With a budget of $101 million in 1996, ESO has been growing and developing steadily throughout the years at Garching and La Silla.

The 3.58-meter New Technology Telescope (NTT), equipped with an active optics system to keep the principal mirror at peak performance, has been in service since 1989. The NTT telescope structure, an altazimuth mounting 5 by 6 by 12 meters (which is rather small for



Two of La Silla's largest and most majestic domes sit high atop the 7,700-foot mountain: the 3.6-meter telescope and the 1.4-meter CAT.

its big mirror), rotates around one vertical and one horizontal axis. The mirror itself is only 24 centimeters (9 inches) thick yet weighs six tons. Such a thin mirror becomes deformed as the telescope moves. To compensate, a computer monitors the focal plane and orders 75 active pads supporting the mirror to move up or down, correcting its shape and obtaining a superb focus.

At the Nasmyth AB focus, the light beam can be diverted into two different instruments, allowing infrared and visual observations of the same object. This technological wonder was built for only $14 million. It is housed in an octagonal, rotating building 16 meters (52 feet) high and 16 meters wide. The building opens completely, exposing the telescope to the external environment. It also rotates with the telescope around a common vertical axis. To avoid heating turbulence produced by the whole system during night observations, the building's floor is cooled and the telescope and instrument rooms are kept at the same temperature as the outside.

ESO uses the NTT as a test ground for technologies and designs to be implemented in the Very Large Telescope. NTT has been the prototype of the new generation of instruments being built all around the world.

Exploring the Universe

Many great astronomical discoveries originated from ESO telescopes. Their mirrors collected the photons from the first observed binary quasar; the most distant known object (quasar Q0000-26); the Cloverleaf Quasar (a rare gravitational lens); the first image of the galactic center; and the most distant star ever seen (a supernova exploding 5 billion light years away in a distant galaxy). The first visible light image of a large disk of material surrounding the young star Beta Pictoris was collected at La Silla in 1987. ESO telescopes have been superb instruments with which to follow Supernova 1987A in the Large Magellanic Cloud and Comet Halley in its hibernation state far from the sun.

Jorge Ianiszewski

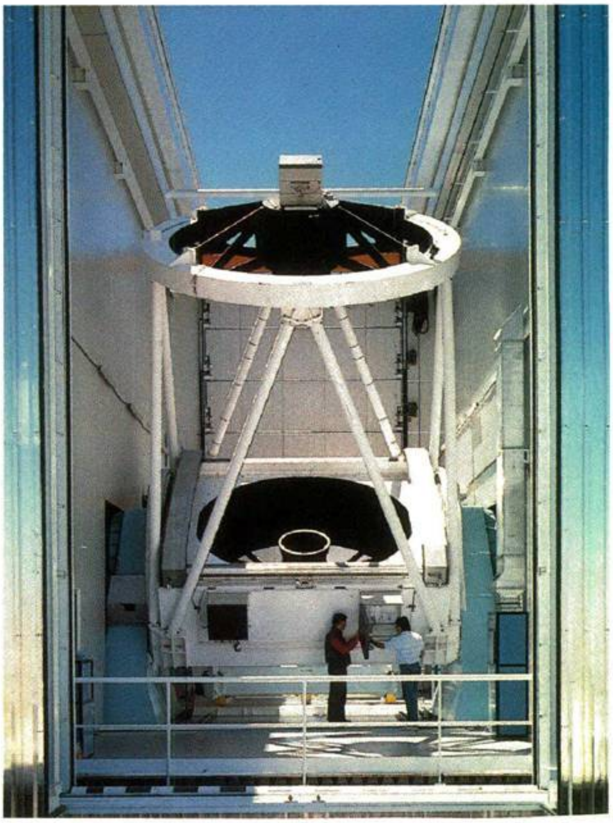
Jorge Ianiszewski

A Chilean cook prepares lunch for La Silla's astronomers and staff.

La Silla will continue to do great science for many years as the best European astronomers use its instruments. In addition, the ESO collaboration allows large investments to be allocated to astronomical science and the development of instrumentation and software.

In astronomy, long-range projects allow large data collection on a variety of subjects, data that is ready to be used by scientists all around the globe to reshape our view of the universe. La Silla and ESO are indeed in the front line of cosmic exploration. □

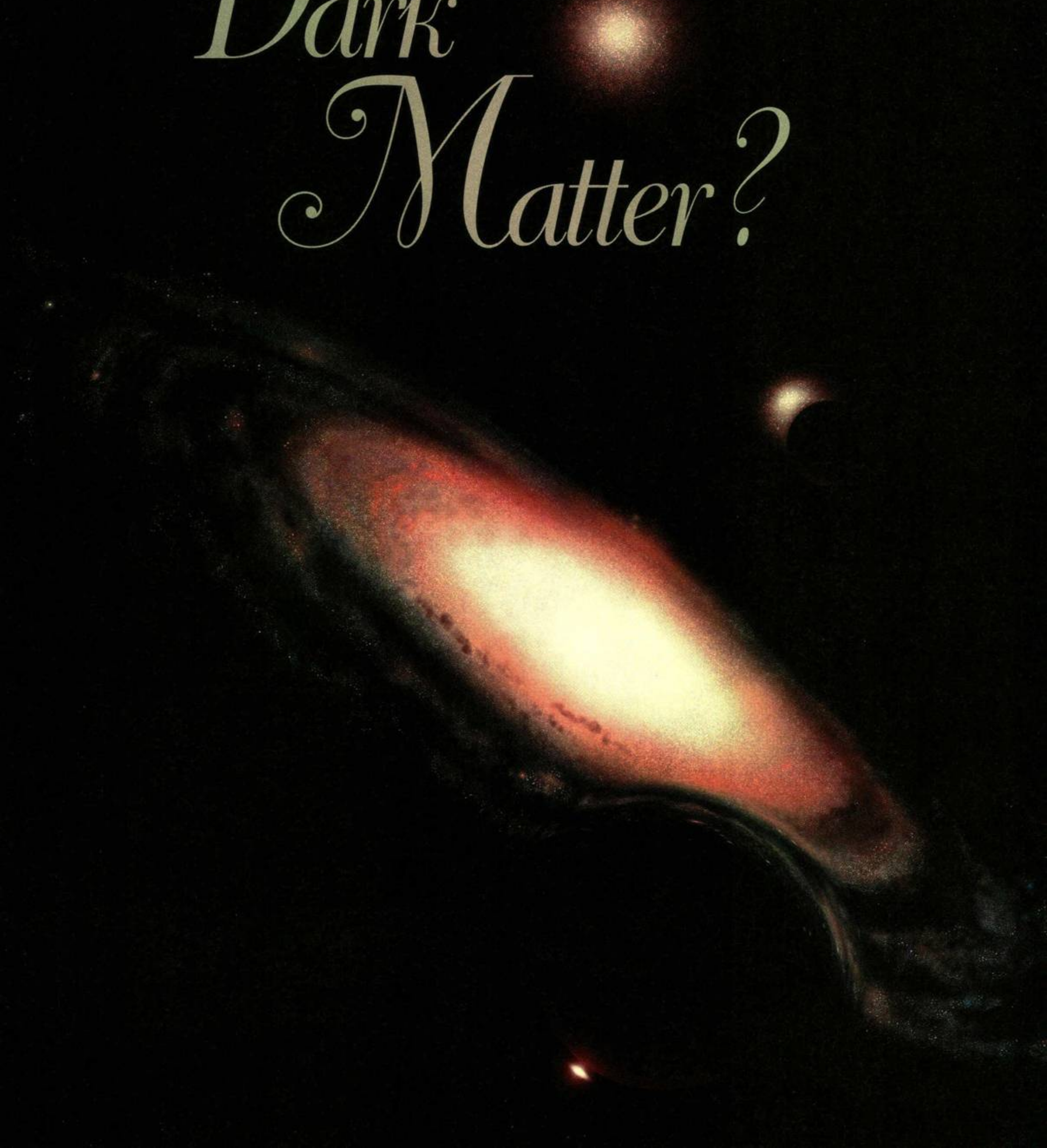
Jorge Ianiszewski (jorgeia@intercon.cl) is a science writer based in Santiago, Chile. He is author of the book Guía a los Cielos Australes (Guide to the Austral Skies).



European Southern Observatory

The New Technology Telescope building opens up to expose the instrument to the night environment.

What is Dark Matter?



If you look at the sky on a clear night, you can see a few thousand stars. With a telescope you can see a lot more — distant galaxies, gas clouds, and dust between the stars. All of this stuff either gives off light or absorbs it. Indeed, if stars didn't give off light, we wouldn't know they were there.

Over the past few decades, astronomers have come to realize there is a lot of matter in the universe that emits little or no light. Called, appropriately enough, "dark matter," we know it only through its gravitational effects. It is as if we could never see the moon but had to infer its existence from the ocean tides.

The presence of dark matter is exhibited in the behavior of rotating galaxies like the Milky Way. The bright spiral arms of these galaxies are permeated by a diffuse sea of hydrogen that gives off faint radio signals. By plotting these signals, astronomers can figure out the movements of the hydrogen. In most galaxies measured, an astonishing fact emerges — like leaves on a stream, the hydrogen is moving as if it were still caught up in the general flow of the galaxy. The most direct conclusion that can be drawn from this is that most galaxies are surrounded by a huge halo of material that doesn't emit detectable amounts of radiation but that does exert a gravitational force. When you put in the numbers, you find that typically at least 90 percent of a galaxy like our own Milky Way is made up of this dark matter.

> The question of what the universe is mostly made of will be decided in the good old-fashioned way — by experiments and observations.
>
> By James Trefil

Other studies have picked up dark matter between galaxies in clusters, where the gravitational force holds the cluster together much more tightly than would be expected on the basis of the gravitational attraction between the bright parts of the galaxies. It's not an exaggeration to say that we've found dark matter everywhere we've looked for it. So the universe is more than 90 percent dark matter, whose very existence was unsuspected until a few decades ago.

What Is It?

In answering this question, scientists divide into two camps, which I'll label the "baryonists" and the "exotics." The term "baryon" (from the Greek for "heavy ones") refers to stuff like the protons and neutrons that make up ordinary materials. Baryonists argue that the dark matter is ordinary stuff that we just haven't detected yet — Jupiter-sized objects out between the galaxies, for example. Exotics, on the other hand, argue that dark matter has to be something new, something never before seen by humans. They pick their candidates from a stable of hypothetical particles that various theoretical physicists have dreamed up over the years but that have not yet been seen in the laboratory.

One field of battle is theoretical. In this game, scientists consider how a particular type of dark matter would fit into our theories of the early stages of the universe. Would this type of dark matter be expected to give rise to the enormous structures of clusters and superclusters of galaxies we see when we look out into the heavens? Would another type explain why all galaxies seem to be so similar in size? My sense is that this argument will not be settled, because theorists on both sides will always be able to patch up their pet ideas just enough to match the (scanty) data.

So the question of what the universe is mostly made of will be decided in the good old-fashioned way — by experiments and observations. In 1993, the first gun in this war was fired when two teams of astronomers announced the detection of dark objects circling the Milky Way. They had monitored millions of stars in the Large Magellanic Cloud (a small suburban galaxy near the Milky Way), watching for a star to brighten and dim over a period of a few days. The idea is that as a massive dark object comes between us and the star, the object will act like a lens and bend the light from the star, making the star look temporarily brighter. Dozens of such brightenings have been seen. The dark objects are called MACHOs (MAssive Compact Halo Objects) and are most likely made from baryons. In 1996, one group of astronomers announced new results which suggest that up to 50 percent of the dark matter in the Milky Way is made of MACHOs, probably in the form of burnt-out stars.

At the same time, more direct searches for dark matter are taking place in laboratories around the world. The idea of these experiments is that if we are indeed immersed in a sea of dark matter, then Earth's motion through it should produce a "dark-matter wind," much as driving a car creates a breeze on a still day. Using blocks of perfect silicon crystals cooled to within a fraction of a degree of absolute zero, physicists are waiting for a particle of dark matter to collide with a silicon atom, depositing enough energy to disturb the crystal. These experiments look most specifically for the exotic particles known as WIMPs (Weakly Interacting Massive Particles). If the experiments are successful, we will learn that just about all of our efforts in exploring the universe so far have been focused on a tiny fraction of the matter out there and that completely new forms of matter exist whose nature and effects on us are still waiting to be discovered. □

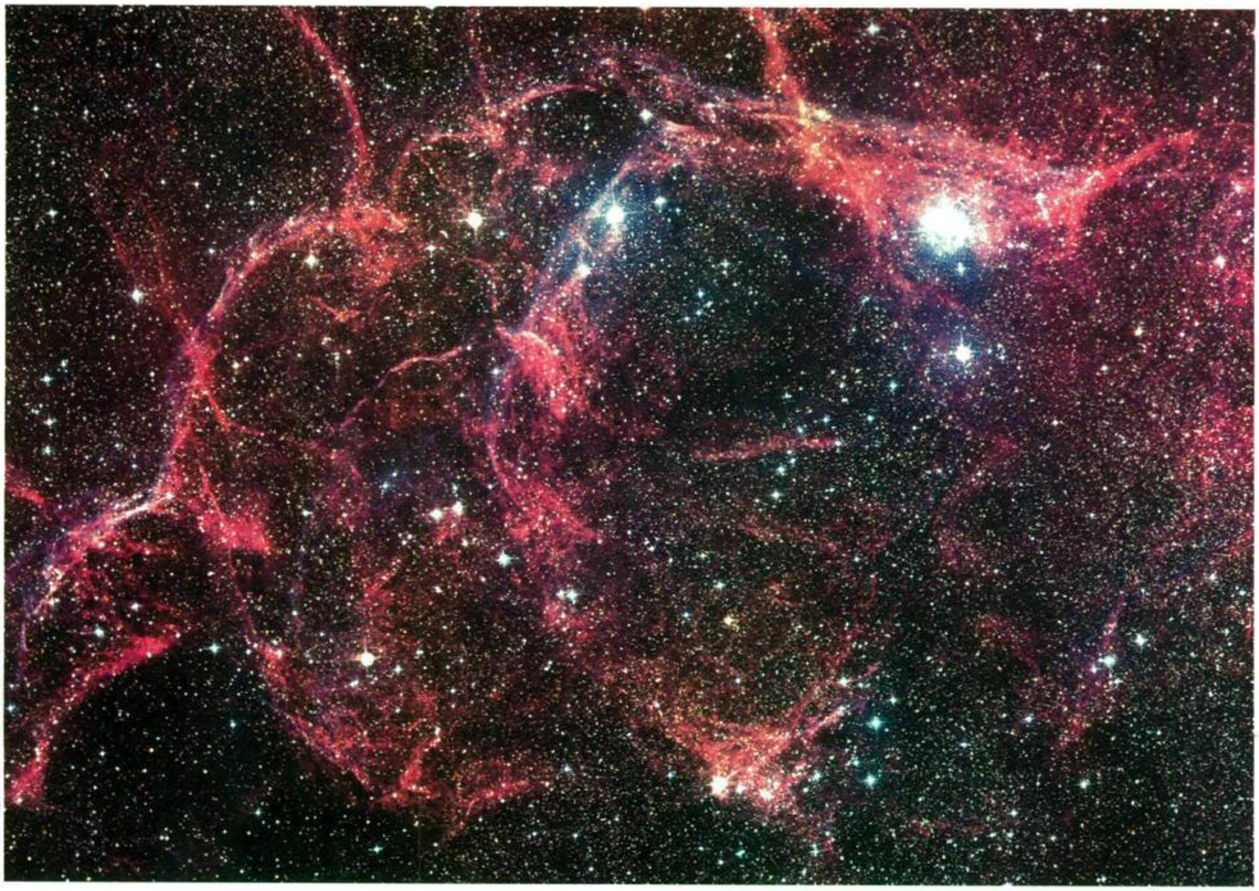
James Trefil is Clarence J. Robinson professor of physics at George Mason University in Fairfax, Virginia. He has authored or co-authored more than 20 books and he is a member of ASTRONOMY*'s editorial advisory board.*

From the book The Edge of the Unknown *by James Trefil. Published by Houghton Mifflin Company, Boston. Copyright © 1996 by James Trefil. Reprinted by permission.*

Anil Rao

The Biggest The Brightest The Best

by Sally Stephens



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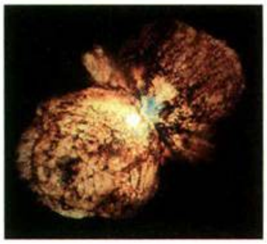
Wispy tendrils from a long-dead star, the Gum Nebula stretches for 60°, making it the largest supernova remnant visible from Earth.

Come on — admit it. You read trivia columns in the newspaper and test yourself on *Jeopardy*. There's just something about knowing the biggest, farthest, or most anything. So for all you trivia buffs out there, here's a random sampling of astronomical record holders. Keep in mind that these are superlatives that have actually been observed and measured. There may be bigger, smaller, and farther things out there, we just haven't seen them yet. But, some day, we might.

Most Massive Star

In the Milky Way Galaxy, Eta Carinae holds the record, tipping the scales at 100 times the mass of the sun. For hundreds of years, it was one of the brighter stars visible in the southern sky. But the life of a hypergiant star is an unstable one, and, in the 1840s, Eta Carinae exploded. (Unlike in a supernova, the explosion did not destroy the star.) It flared briefly to become the second brightest star in the sky, after Sirius, and ejected more matter into space than the total contained in our solar system. That material now blocks most of the star's brilliant light from reaching us, although we can see light from other nearby massive stars that form a tight-knit group with their most massive sibling.

A challenger to Eta Carinae's claim as the most massive star known lies in the Large Magellanic Cloud, a satellite galaxy to our own Milky Way. HDE 269810, known by its catalog name, may be 190 times as massive as the sun. However, we've been fooled in the past by tight clusters of massive stars masquerading as a single star until astronomers could disentangle their light. (Eta Carinae is one such example.) Only time will tell if HDE 269810 unseats the champ or not.


Jon Morse (Univ. of Colorado) and NASA

Largest Supernova Remnant

The Gum Nebula, named after astronomer Colin Gum who first noticed it, spans 60° of the southern sky and is centered on the constellation Vela. (It is sometimes called the Vela supernova remnant.) It appears large because it is actually very close; its center lies about 1,300 light-years away, while the nearest edge comes within 330 light-years of us. Analysis of the remnant's expansion rate indicates that the massive star that created it blew up around 9000 B.C. At its brightest, the exploding star was probably as bright as the quarter moon. No doubt it had a profound impact on the Stone Age people who watched it.

Fastest Moving Star

An asymmetric supernova explosion gave the pulsar named PSR 2224+65 a swift kick during its creation, sending it careening through space at up to 1,000 miles per second (1,600 kilometers per second). The pulsar's rapid motion has left a guitar-shaped cloud of faintly glowing gas and dust in its wake. PSR 2224+65 moves so fast that it will eventually escape from our galaxy, condemned by a quirk of its birth to roam the empty space between the galaxies forever.

Most Elongated Object in the Solar System

When the asteroid 1620 Geographos cruised past Earth in August 1994, astronomers bounced radar waves off its surface. The return echoes revealed that the asteroid is shaped like a sweet potato, measuring 3.2 by 1.1 miles (5.1 by 1.8 kilometers). That makes it the most elongated object in the solar system.

Largest Planetary Nebula

The largest known planetary nebula surrounds the X-ray source RX J2117 in the constellation Cygnus. This expanding cloud of gas appears to be about 13 arcminutes across, about half the diameter of the full moon. At its calculated distance of 4,600 light-years, the nebula actually spans 17 light-years. The nebula was discovered with the 0.6-meter Mather Telescope at the E. W. Fick Observatory of Iowa State University, which may make the Mather the smallest telescope to have ever discovered the biggest anything.

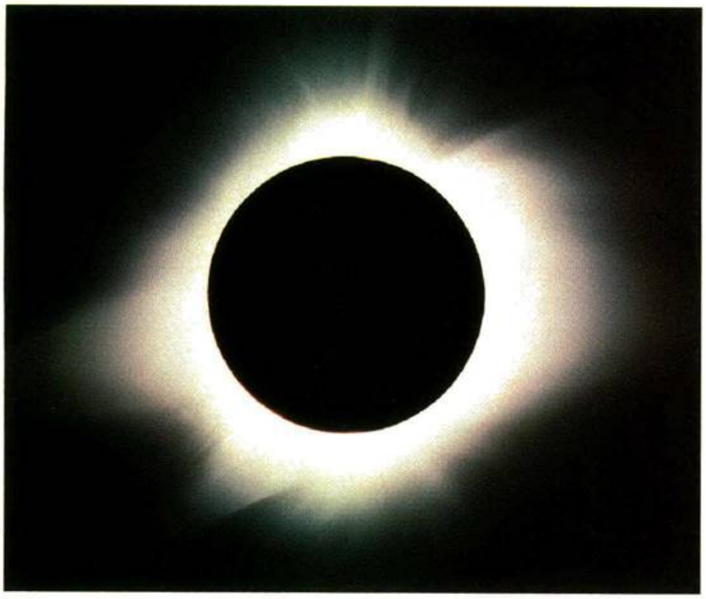
Biggest Meteorite

The largest single meteorite known, weighing 60 tons, lies partially buried in the ground on the Hoba West farm near Grootfontein, Namibia, in southern Africa. The iron meteorite, known as Hoba, was discovered in 1920. Its upper surface, lying almost flush with the ground, is roughly square, measuring 116 by 112 inches (295 by 284 centimeters), while its depth varies from about 40 inches (100 centimeters) on one end to 20 inches (50 centimeters) on the other. Hoba is so massive it has never been moved from where it struck Earth. The largest meteorite "in captivity" resides in the American Museum of Natural History in New York City. One of three iron meteorites brought back from Cape York, Greenland, by Admiral Robert Peary in 1897, the Ahnighito ("tent") meteorite weighs in at just over 34 tons.

Greatest Meteor Shower

On the night of November 16/17, 1966, observers in the western United States witnessed the greatest meteor storm in history, with upwards of 144,000 meteors an hour reported. The intense storm, part of the annual Leonid meteor shower, lasted for more than an hour. Although the debris cloud that created the storm was dense by interplanetary standards, each meteoroid was actually about 15 miles (24 kilometers) from its nearest neighbor.

Charles Capen



Bob King

On July 16, 2186, the sun's corona will remain in view for 7 minutes and 29 seconds, the longest period of totality in four millennia.

Farthest Galaxy

Only a handful of quasars are more distant than an anonymous galaxy located in the constellation Virgo, discovered in 1996. With a redshift of 4.38 (the previous record holder, radio galaxy 8C 1435+63 in Draco, had a redshift of "only" 4.25), the faint galaxy lies between 8 and 12 billion light-years from Earth, depending on the exact cosmological parameters used in the calculation. Astronomers think this galaxy is very young, perhaps only 100 million years old, and converts gas into stars at a rate of 30 solar masses per year.

Biggest and Smallest Satellites

The giant planet Jupiter's stable of 16 moons appropriately includes the largest in the solar system. Ganymede (top photo), at 3,270 miles (5,262 kilometers) across, is even larger than the planet Mercury. It is composed of roughly equal parts ice and rock, and probably formed out of a disk of gas and dust that surrounded the infant Jupiter, in much the same way the planets formed in a disk around the young sun. Jupiter's Leda, at 10 miles (16 kilometers) across, almost wins as the smallest satellite in the solar system, but it is barely beaten out by the martian moon Deimos. Just 9 miles (15 kilometers) across in its longest dimension, Deimos (bottom photo) is probably a wayward asteroid captured by Mars's gravity.

NASA/JPL

Longest Total Solar Eclipse

Because of the speed with which the moon's shadow crosses Earth, totality can never last more than 7 minutes 31 seconds. Usually it is much less than that, due to variations from eclipse to eclipse in the angle of the sun and the distance between Earth and the moon. The longest total phase between 2004 B.C. and A.D. 2526 will take place on July 16, 2186, with totality lasting 7 minutes 29 seconds. The longest in the 20th century occurred on June 20, 1955, when totality lasted 7 minutes 8 seconds and could be seen from the Indian Ocean, Southeast Asia, and the Pacific Ocean.

Biggest Galaxy in the Universe

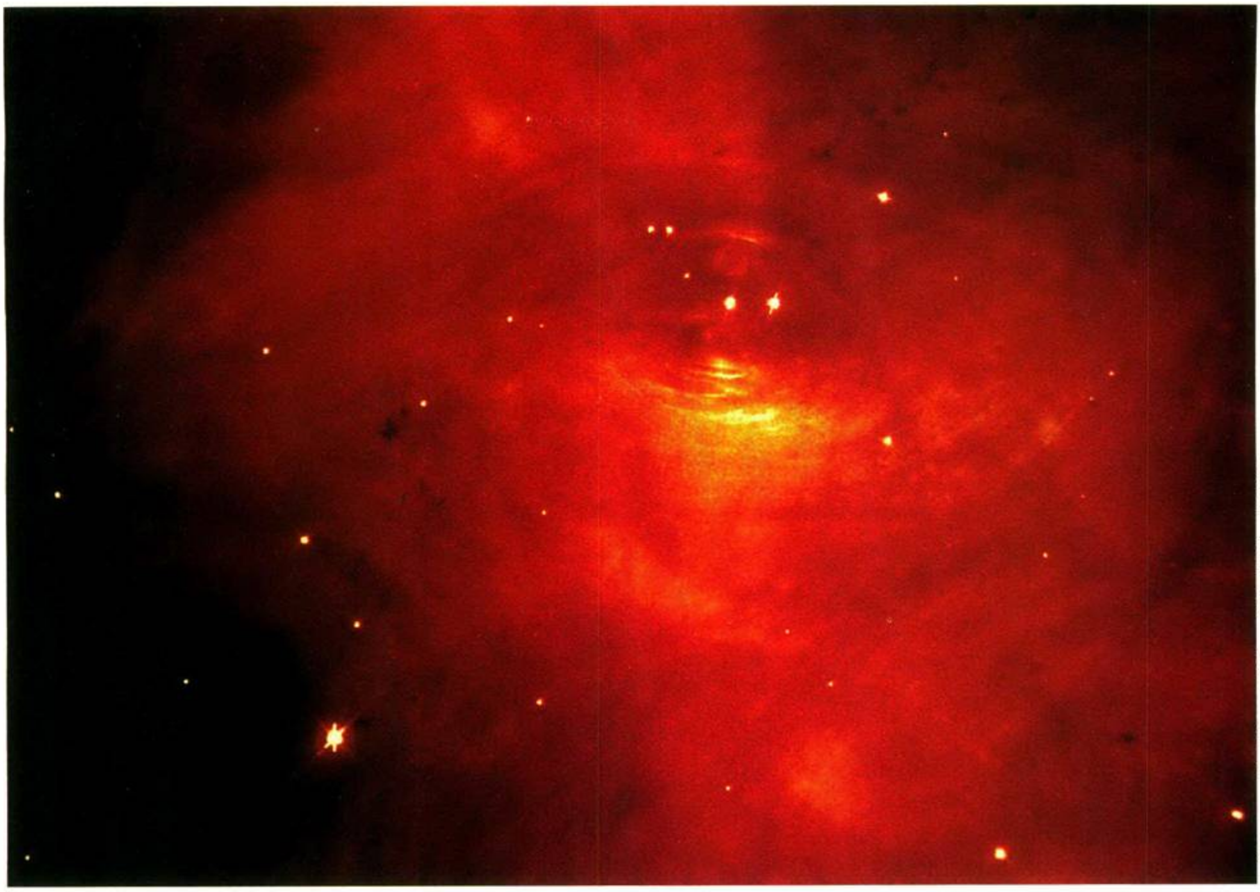
The galaxy 3C 236 has two lobes of radio emission that each stretch nearly 4 million light-years in opposite directions from the center of the galaxy. This radio galaxy thus extends about four times as far as the distance between the Milky Way and Andromeda galaxies. Astronomers assume that jets of high-speed particles carry energy from the galaxy's central regions into the immense lobes. The total energy in the radio lobes of a galaxy such as 3C 236 may exceed 10^{61} ergs — more than that released by 10 billion supernovae.

Slowest and Fastest Rotating Pulsars

As neutron stars spin, beams of energy emitted from their magnetic poles sweep across the sky like lighthouse beacons. If the beams cross our line of sight, we see them as pulses of radio energy and so call them pulsars. By measuring how fast the radio pulses arrive, we can calculate how fast the pulsar is spinning. The slowest so far observed is known by its coordinates J1951+1123, and spins once every 5.094 seconds. The fastest, which presumably "spun up" when material from a companion star fell onto it, is the millisecond pulsar B1937+21, which spins once every 0.00156 second. If it were spinning any faster, the pulsar most likely would tear itself to pieces.

Largest Star

The red supergiant star Mu (μ) Cephei may be the largest star known. Sometimes called the "Garnet Star" because it possesses a distinctly reddish color, it has a radius of 11 astronomical units, or 11 times the distance from Earth to the sun. If Mu Cephei could be placed at the center of our solar system, its tenuous outer atmosphere would swallow up all of the planets out to and including Saturn.



Jeff Hester and Paul Scowen (Arizona State Univ.) and NASA

In the heart of the Crab Nebula, the most energetic pulsar known (the left-hand star in the pair above center) powers the nebula.

Most Energetic Pulsar

As pulsars age, their rapid rotation slows. This gradual slowdown ultimately powers all their emissions, as the kinetic energy of rotation is converted to various forms of electromagnetic energy. Astronomers define the spin-down luminosity of a pulsar as the rate at which the star loses its kinetic energy of rotation. By this measure, the most energetic pulsar is the famous pulsar at the heart of the Crab Nebula. Currently spinning once every 0.033 second, the Crab pulsar is losing energy at the astonishing rate of 5×10^{38} ergs each second. That's 100,000 times more energy than the sun radiates!

Closest Approach by an Asteroid to Earth

On December 9, 1994, an asteroid the size of a small house raced past Earth, missing our planet by only 60,000 miles (100,000 kilometers). That's only about one-quarter the distance from Earth to the moon. The asteroid, 1994 XM_1, had been discovered just 14 hours before the moment of closest approach as part of a project to find and identify asteroids and comets that might someday strike Earth. This time, it missed.

Most Energetic Supernova

When a massive star dies and its central core collapses, it releases a tremendous amount of energy, almost all of it carried away by neutrinos. When Supernova 1987A exploded in the Large Magellanic Cloud on February 23, 1987, detectors on Earth observed the neutrino burst for the first time ever, allowing astronomers to more accurately measure the total energy released. As a result, it ranks as the most energetic supernova yet gauged, with a total energy in the explosion of 3×10^{53} ergs, or more than a hundred billion billion times the energy given off by the sun. For several seconds after the explosion, Supernova 1987A shone brighter than all the stars in all the galaxies in the rest of the universe.

Jim Barclay

At closest approach in March 1996, the tail of Comet Hyakutake stretched about 100°, equaling the longest comet tail ever seen.

Brightest Supernova

On May 1, 1006, a new star suddenly appeared in the constellation Lupus in the far southern sky. At maximum light, it was brighter than the quarter moon, so bright it cast shadows at night and could be seen during the day. Ancient scribes in Europe, the Middle East, and the Orient chronicled its appearance, fearing it foretold war and famine. Although the records are a bit sketchy, the supernova may have been visible to the naked eye for more than two years before finally fading from view. Astronomers studying the region of the sky described by the ancient reports have found a faint, wispy nebula, all that's left of the brightest supernova ever observed.

Hottest Star

HD 93129 A, at a temperature of 45,000 kelvins, ranks as the hottest normal star. But at 200,000 kelvins, the central star of the planetary nebula NGC 2440 may be the hottest star ever observed. The nebula formed when an aging sun-like star threw off its outer layers, exposing the stellar core. This "naked" core is the hottest star.

Sally Heap (NASA/GSFC)

At a scorching 200,000 kelvins, the central star of the planetary nebula NGC 2440 in Puppis is the hottest star yet measured.

Largest Sunspot

A group of sunspots that first appeared in April 1947 was the largest ever observed. The group consisted of two large sunspots and several much smaller ones that covered an estimated six billion square miles, more than one percent of the disk of the sun. More than 100 Earths could have fit within the huge group.

Closest Galaxy

A faint, stretched-out, dwarf spheroidal galaxy in the constellation of Sagittarius, discovered in 1994, has proven to be our nearest galactic neighbor. Located about 80,000 light-years from Earth on the opposite side of the Milky Way's center (it's about 50,000 light-years from the galaxy's center), the dwarf galaxy is more than three times closer than the Large Magellanic Cloud, the previous record holder. As it passes close to the Milky Way, the dwarf galaxy is being pulled apart by our galaxy's gravity. The galaxy has been stretched to about 10,000 light-years across, ten times the normal diameter of a dwarf galaxy. Eventually many of its stars will merge with those in the Milky Way, and it will cease to exist as a separate galaxy.

Most Distant Object in the Universe

In 1991, astronomers searching for distant quasars with the 200-inch Hale Telescope on Palomar Mountain came across one that they called PC 1247+3406 (its coordinates). It proved to be the most distant ever found, with a redshift of 4.897. This implies that the quasar is moving away from us at a velocity, due to the expansion of the universe, of nearly 95 percent the speed of light. This redshift corresponds to a distance of 8 to 15 billion light-years, depending on what assumptions you make about the expansion of the universe. It is so distant that we see the quasar as it was when the universe was only 7 percent of its current age.

Gerald Rhemann and Franz Kersche

Longest Comet Tail

Few observations are as imprecise and subjective as gauging the length of a comet's tail. Until a year ago, two comets ranked in a virtual tie for having the longest tail: Comet Halley and Comet Tebbutt. Halley made its closest approach ever to Earth in A.D. 837, passing just 3 million miles (5 million kilometers) away on April 10. Three days later, Chinese astronomers estimated that the comet's tail stretched 90° to 100°. Comet Tebbutt, also known as the Great Comet of 1861, reportedly had a similar tail length when it passed Earth more than a century ago.

The March 1996 appearance of Comet Hyakutake elevated a third comet into this elite group. Some observers estimated Hyakutake's tail covered up to 100°, putting it right up there with the other two. Because no single observer could possibly view all three comets, it's probably best to rate this category as a three-way tie.

Richest Galaxy Cluster

Abell 665, a galaxy cluster in Ursa Major, is the only one listed in astronomer George Abell's catalog of over 2,000 galaxy clusters that is given the highest possible "richness" class of 5. He estimated that Abell 665 contains over 3,000 galaxies, including those too faint to be seen.

Most Distant Object in the Solar System

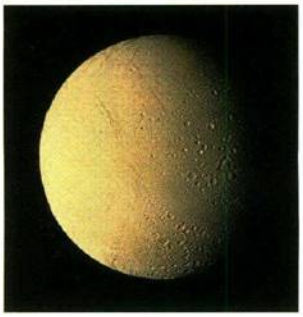
For years, astronomers assumed that Pluto, with an average distance from the sun about 40 times greater than that of Earth, would remain the farthest object in the solar system that we could see. But in the last few years, several dozen objects have been detected out past the orbit of Neptune. Part of the so-called Kuiper Belt, the objects are icy debris left over from the solar system's formation. By the end of 1996, the object known to travel farthest from the sun is an icy rock designated 1996 TL_{66}. At its most distant point, it lies 132 astronomical units from the sun. Although some long-period comets travel beyond this distance, they remain too faint to be seen.

Closest Approach by a Comet to Earth

In 1767, Jupiter's powerful gravity changed the orbit of Comet Lexell to one that would bring it close to Earth. The comet then streaked within 1.40 million miles (2.26 million kilometers) of Earth — just under six times the Earth-moon distance — on July 1, 1770. So close was this passage that Earth's gravity actually shortened the comet's period around the sun by three days. When the comet didn't return as expected in 1776 or 1781, astronomers Anders Johann Lexell and Pierre Simon Laplace painstakingly calculated the comet's motion over time (no simple feat in the days before computers) and discovered that another close approach to Jupiter in 1779 had again radically changed the comet's orbit. This time, it may have been sent out of the solar system altogether.

Brightest Surface in the Solar System

Saturn's moon Enceladus appears brighter than newly fallen snow, reflecting almost 100 percent of the sunlight that falls on it. Astronomers think its surface is covered with fine crystals of pure ice, looking somewhat like the glass beads on a projection screen. Its surface also has fewer impact craters than most other satellites, which implies that the 300-mile-wide (500 kilometers) moon may be geologically active. It's possible that Enceladus has volcanos that spew water ice rather than rocky lava, although no such geysers or vents have actually been seen. Ice crystals blown off of Enceladus may also have created Saturn's thin E ring.



NASA/JPL

Sally Stephens is a science writer living in San Francisco. Her previous article for ASTRONOMY, *"The Excesses of Youth," appeared in the September 1996 issue.*

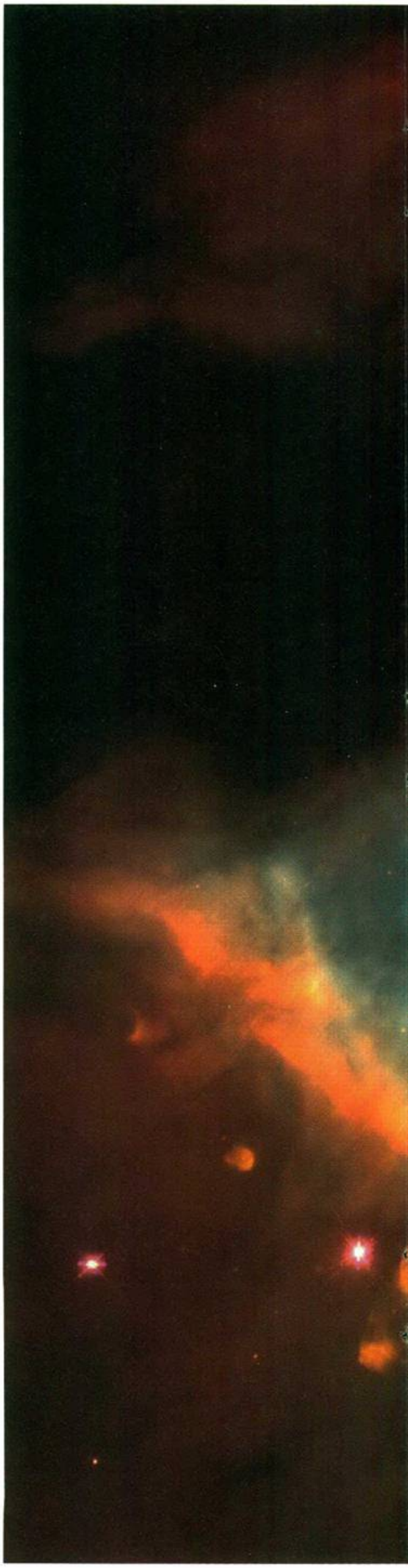
Stars that Zap their Neighbors

Hubble images of Orion's central regions show protoplanetary disks being cooked and destroyed by their stellar neighbors.

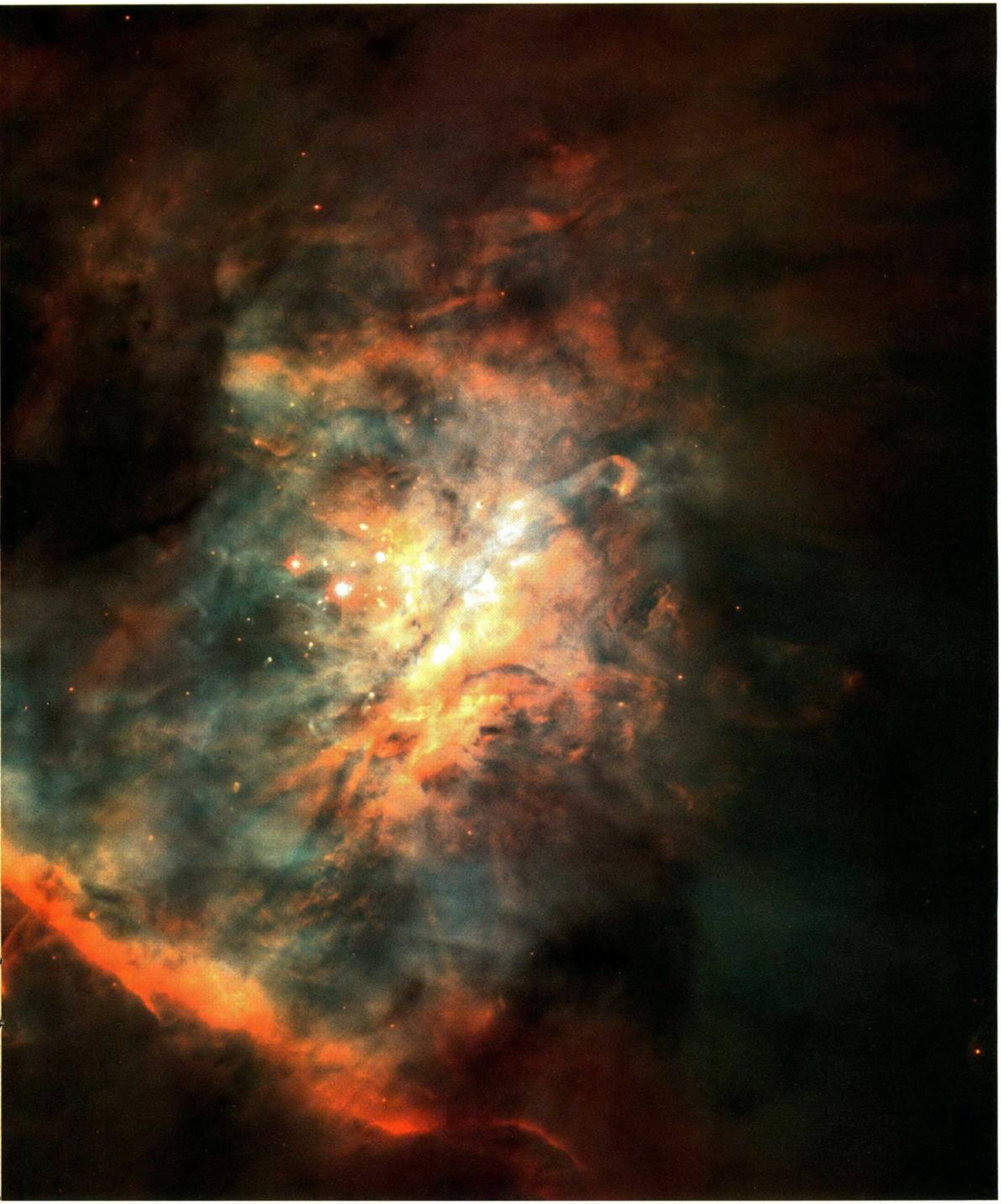
by Robert Naeye

Since space shuttle astronauts installed corrective optics in December 1993, the Hubble Space Telescope has imaged a plethora of gaseous, dusty disks surrounding newborn stars. Using Hubble, astronomers have found 153 in the Orion Nebula alone, implying that disks are a common by-product of star formation. The planets in our solar system formed from accreting material inside a disk that was very similar to the ones that are turning up in the Hubble images. For those who hope the galaxy is chock full of life, this is good news.

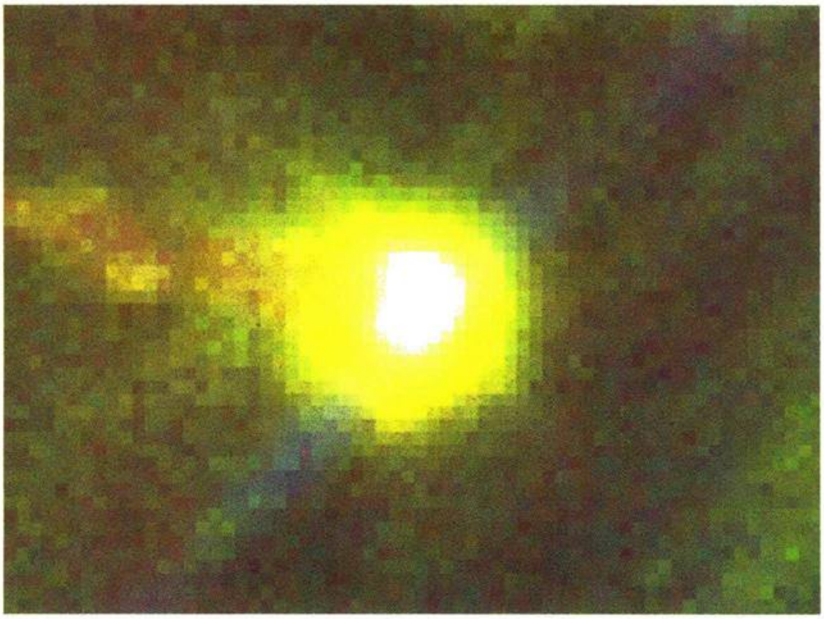
But stop the presses — hold on just a minute. New analysis of the Hubble Orion images shows that some disks might not last long enough to form planets. They have the misfortune of living in a hostile environment where their closest stellar neighbors are the proverbial neighbors from hell. "It's kind of sad that what we are seeing here is quite likely the destruction of protoplanetary disks, disks that may very well *not* form planets," says Doug Johnstone of the Canadian Institute for Theoretical Astrophysics in Toronto. Johnstone and his colleagues David Hollenbach and Herbert Stoerzer of NASA's Ames Research Center developed a model of evaporating disks based on Hubble images taken by John Bally and Dave Devine of the

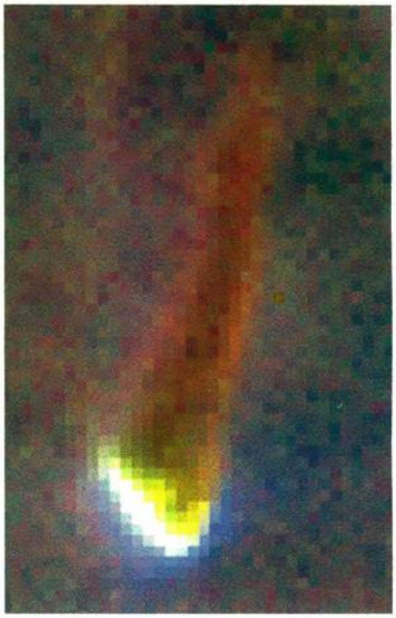


Hubble peers deep into the Orion Nebula, a stellar nursery 1,500 light-years from Earth. The four bright pink Trapezium stars near the center illuminate the nebula.



C. Robert O'Dell (Rice University) and NASA





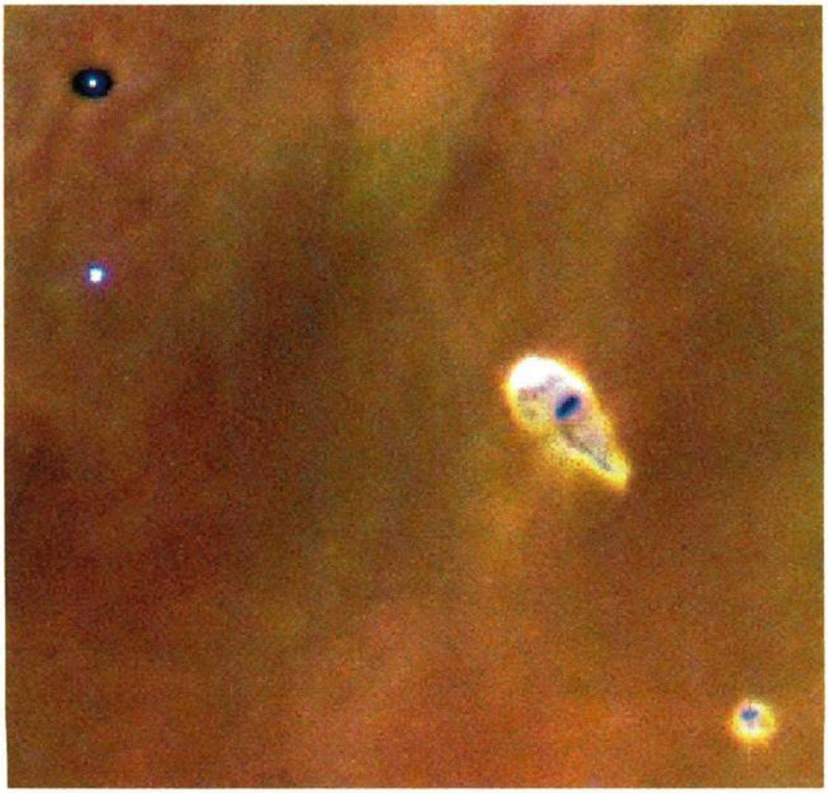
University of Colorado, and Ralph Sutherland of the Australian National University.

The evaporating disks lie within one light-year of the Trapezium cluster, four stars at the center of the Orion Nebula. The Trapezium stars are much larger and hotter than the sun. The fearsome foursome are furiously pumping out ultraviolet radiation. Each photon of ultraviolet light packs a large amount of energy, so a heavy dose of this nasty radiation is bad news for anything in its path. The ozone layer in Earth's atmosphere protects us from the sun's relatively feeble ultraviolet radiation. But each Trapezium star alone produces an ultraviolet flux billions of times greater than the sun's. The most massive of the four stars, Theta^1 C Orionis, is the nastiest of the lot.

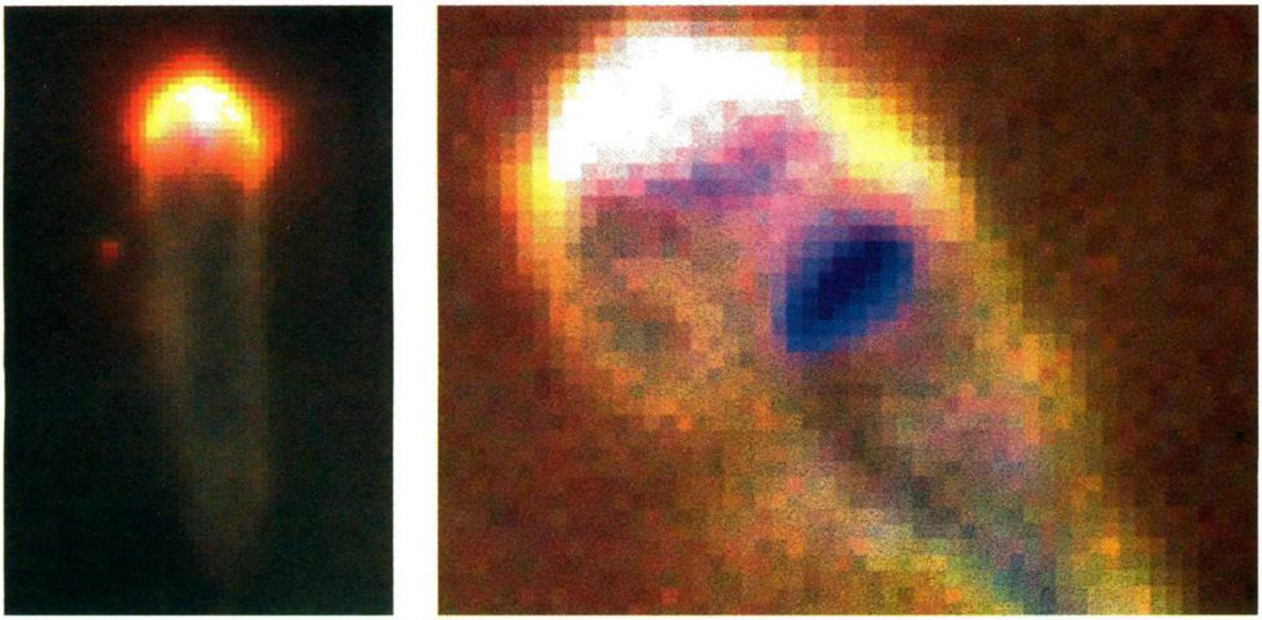
Ultraviolet radiation from the Trapezium rams into the surfaces of the nearby disks, heating their gas and dust to temperatures in excess of 1,800° F, far hotter than a blast furnace. The heated gas now has enough energy to escape the gravitational pull of the host star, so it literally evaporates away. Even higher-energy ultraviolet light from the Trapezium stars heats the evaporated gas to temperatures approaching 20,000° F, forming a bubble of glowing hot, diffuse gas around each disk.

Johnstone's team estimates that these disks are losing about three moon masses per year. The disks started off with about 10 Jupiter masses, meaning it takes only 100,000 years for this process to whittle the disks down. "There's no reason to believe that these disks are any different than the disks that would form planets, except for their environment. So you're seeing the material that would otherwise have formed planets," says Johnstone.

But the news is not all bad. A significant fraction of stars don't form anywhere near such stellar brutes. In addition, because the disks erode from the outside in,



A solar-system-size disk lies inside the teardrop. The Trapezium's ultraviolet light evaporates material from the disk's surface, forming a cocoon of diffuse hot gas.

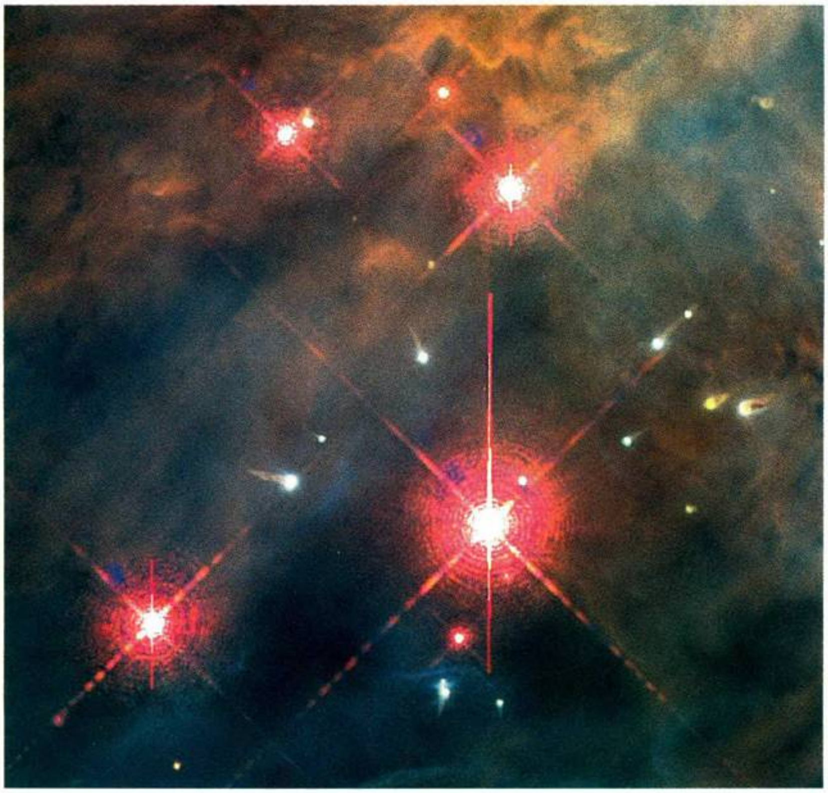


it's quite possible that small, rocky terrestrial planets could form in the inner part of the disks before the disks completely disappear. But gas-giant planets like Jupiter are probably ruled out. Planet formation models predict that it takes a planet at least 10 million years to accrete a Jupiter's worth of material, so it's likely that a disk will be eroded long before that can happen. "You either have to form planets really early or you have to form planets in the inner parts of the disk," says Johnstone.

Johnstone says that the very destruction of the disks helps astronomers study them. "Because these things are being destroyed, it's very similar to trying to understand your TV set by blowing it up — you get to see what's inside. We're lucky that we can look at such a destructive environment because it gives us a chance to observe the material and perhaps to even learn about the circumstellar disks by watching them being destroyed. We see them evaporating today, we know how big the disks are, therefore that tells us how big they must have been in the past and how much mass they must have had."

The idea of evaporating disks is not completely new. Based on ground-based radio observations, University of Wisconsin astronomer Edward Churchwell first hypothesized in the 1980s that brightly emitting objects in the Trapezium region were evaporating disks. "The difference now is that we have gorgeous pictures where you can actually see what's happening," says Johnstone. □

Say goodbye to planets. The Trapezium stars bathe their stellar neighbors with nasty ultraviolet light. Many of these unfortunate stars are surrounded by disks of gas and dust similar to the one that formed the planets in our solar system. Right before our eyes, Hubble shows ultraviolet radiation literally evaporating material in the disks, possibly preventing planets from forming.



Intense ultraviolet light from the brightest of the Trapezium stars, Theta^1 C Orionis, pushes material away, forming the tail-like structures pointing away from it.

All photos on this spread by John Bally, Dave Devine (Univ. of Colorado), Ralph Sutherland (ANU), and NASA

Was the Universe Designed for Life?

COMING TO TERMS WITH THE ANTHROPIC PRINCIPLE

BY JAMES TREFIL

From the point of view of a physicist, whenever anything happens in the world, it happens because of the action of some combination of four fundamental forces. The forces of gravity and electromagnetism are familiar to us from our everyday existence, and if we add the strong force (which holds nuclei and elementary particles together) and the weak force (responsible for certain types of radioactive decay), we've pretty well exhausted nature's bag of tricks.

One important thing to realize about these forces is that they have different strengths. A magnet that will fit your hand, for example, can lift up a nail even when the entire Earth is on the other side pulling down with the force of gravity. This should convince you that the magnetic force is by far the stronger of the two. In fact, although you may not believe it after you and your friends maneuver a couch up a flight of stairs to a second floor apartment, gravity is the weakest of the four forces. (The most powerful, as you might guess from the name, is the force that holds the nucleus of the atom together).

All this is by way of introduction to one of the most persistent and hotly debated ideas in modern cosmology — the anthropic principle. This notion suggests, to some thinkers at least, that the universe appears the way it does because we are here to see it.

One way of getting to the principle is to play "What If?" games with the forces of nature. For example, if the force of gravity were about 100,000 time weaker than it is, a good pitcher with a 100-mile-per-hour fastball could propel a baseball fast enough to allow it to escape Earth's pull and move into space. Make the gravitational force a few orders of magnitude smaller than this and you could join the baseball just by jumping. And while this sort of game may seem pointless, if we apply it to the standard Big Bang picture of

Timothy Cook

the universe some startling results emerge.

You may remember that the Big Bang happened this way: In its early stages, the universe consisted of a dense, hot soup composed of the elemental constituents of matter. As time went by, the universe expanded and cooled, as hot, dense things will. At specific stages, the dropping temperatures reached critical values that allowed various components of our current universe to condense out of the soup, much as frost condenses out of the air on cold mornings. When the universe was a little older than three minutes, for example, the nuclei of certain light atoms condensed out, and sometime before the million year mark, galaxies and stars started to form.

The important point is that the rate of expansion of that early universe depended on the size of the gravitational force. Had the gravitational force been significantly weaker than it is, outrushing bits of the early universe would have behaved like the baseball in the example above — they would have moved out much faster. This would have had at least two important consequences for the subsequent history of the universe.

The formation of nuclei at three minutes depended on the rate at which protons and neutrons collided with each other in the primeval soup. This rate depends on the density of the particles present (the denser they are, the more collisions) and hence on the rate of expansion which, in turn, depends on the strength of the gravitational force. So if the gravitational force were significantly weaker than it is in our universe, the formation of nuclei in the Big Bang would have been significantly different as well.

Moving forward in time a few million years, the stately condensation of the stuff of the universe into galaxies and stars is even more directly related to the strength of gravity. In any cloud of stuff, the prevailing theory holds, there will be regions that have slightly higher densities of matter than their surroundings. These regions will exert a stronger gravitational force than their neighbors and will pull more matter into themselves. This, in turn, makes them more massive and causes them to exert a still stronger gravitational force, which attracts still more mass, and so on. Over time, this kind of gravitational condensation process can be expected to produce the galaxies and clusters of galaxies we observe in the universe. (I should point out that explaining the exact process by which galaxies formed remains one of the great unanswered questions of cosmology).

If the gravitational force were much weaker than it is, then, the formation of stars and galaxies would have been affected in two ways. First, the universe would have expanded faster so that matter would have been more thinly spread and harder to collect together, and, second, the force available to do this collecting would have been much weaker. Were the gravitational force sufficiently small, no stars (or planets) would have formed at all!

What about the other extreme, the one where the gravitational force is much stronger than it is in our universe? In this case, the expansion of the universe would have been much more sluggish as the inward pull of gravity restrained the outward expansion. Those outward rushing bits of the early universe would have been like baseballs thrown on a planet like Jupiter — they would have had a hard time pulling themselves free. In fact, it's not hard to see that had the gravitational force been significantly stronger than it is today, the entire expansion would have been terminated early and the universe would have collapsed like a pricked balloon. In this case, there would also be no stars or planets.

So these simple thought experiments lead to a rather startling conclusion. There is a relatively narrow window of values that the strength of the gravitational force could have had to produce a universe like the one we live in. If we follow the conventional wisdom and say that the existence of stars and planets are essential for the development of life, this argument leads to a conclusion still more startling: Had the strength of the gravitational force been significantly different, life could not have appeared in our universe.

And although I have used the gravitational force as an example to make this point, I could equally well have used any of the other forces. The formation of nuclei at three minutes would not have proceeded had the strong force been significantly weaker. Instead of condensing from a mixture of chemical elements, the earliest stars would have been made from hydrogen alone, a fact that would have altered the subsequent chemical history of the universe. Were the strong force considerably stronger than it is, the formation of elements like carbon in stars would have been quite different, as would the patterns of radioactivity. Again, there is a relatively small window of values that would allow the existence of life.

So we live in a universe where the fundamental constants of nature seem to be "fine-tuned" to permit the existence of life and, perhaps, intelligence. Change any of the fundamental constants of nature and you could well have a universe in which no life exists at all.

How one responds to this astounding fact depends, I suppose, on one's temperament. Most scientists don't lose much sleep over it, preferring to say that it's just a coincidence. Among those who want to take the issue more seriously, a debate has arisen over what is called the anthropic principle.

Before going on, I should say that there isn't just one anthropic principle — in fact, it's not too much of an exaggeration to say that there are probably as many versions of this principle as there are authors writing about it. In general, though, the versions tend to fall into two camps, which have come to be labeled "strong" and "weak," respectively.

The Weak Anthropic Principle

According to the weak anthropic principle, the question "Why are the forces of nature as they are?" cannot rightly be considered without recognizing that an intelligent being is asking. In other words, the principle says that it's crucial to take into account not only the content of the question, but also the fact that it is being asked at all. In one of the universes discussed above — the one with no stars, no planets, and no life — the question wouldn't be asked because there would be no one to ask it.

Let me give you an example, so you have a better sense of how this argument works. If you flip a coin, there's a 50-50 chance it will come up heads. Flip it ten times in a row and you will, in general, get a certain number of heads and a certain number of tails (on average, of course, you'd get equal numbers of both). Do a thousand such ten-flip trials, however, and the chances are that in one of them you will see all the flips yield heads — you will get ten heads in a row. You could, of course, zero in on that trial and start asking why you got ten heads in a row, but that would clearly be pointless. By chance, one series like that is going to show up sooner or later, and the fact requires no explanation at all. In just the same way, some proponents of the weak anthropic principle argue, we just happen to be in a universe where all the coins come up heads, or where the forces of nature have just the right strengths to produce life.

My sense is that most working scientists who think about these issues subscribe to some version of the weak anthropic principle. I know that I do. Indeed, it's hard to see how anyone could object to this principle. It's important, however, to realize that the weak principle doesn't really explain anything. It gives a kind of ex post facto gloss to a puzzling fact about the universe we live in, but if you're the kind of person who demands that everything in nature have a purpose, you'll find this sort of argument unsatisfying. You will, in fact, be much more receptive to the strong anthropic principle.

The Strong Anthropic Principle

In its most extreme form, the strong anthropic principle states that the universe must be arranged so that life can develop — that the universe we see around us is, in fact, the only universe allowed by the laws of nature. According to this version of the principle, the universe does not just allow life to develop, but in some sense demands it to develop.

In a sense, the strong principle provides a kind of explanation for the fine-tuning of the universe. It says that every universe must allow for the existence of life, and, as we have seen, this requires that the strengths of the fundamental forces be within a narrow window. Critics point out, however, that this explanation is nothing more than the substitution of one mystery (the demand for life) for another (the fine-tuning of the forces). Why, they ask, does a universe have to accommodate life at all? Have you really added anything to your knowledge by stating things this way?

For me, the strong anthropic principle smacks too much of mysticism to be good science. The fact that it's most eloquent defender was Sir Arthur Eddington, a man who could be called the king of scientific mystics, simply reinforces this feeling. But the question of whether the strong principle (or the weak one, for that matter) is or is not a valid scientific statement is, I think, one that deserves some attention.

The distinguishing feature of science — the thing that makes it different from fields like literary criticism — is its unrelenting demand that all ideas and claims about the universe be checked by experiment on or observation of the universe itself. No matter how clever, an idea can't survive unless it meets this test. I don't think it's going too far to say that if a statement can't be subjected to experimental or observational test, it simply isn't a part of science.

What if we apply this standard to the various versions of the anthropic principle? How could they be verified in the same way that scientists verify something like the Second Law of Thermodynamics?

Since the statements concern properties of the universe, there are only two ways this could possibly be done. One, of course, would be to observe many universes and see if they all contain life. While this may be an interesting exercise in science fiction, it's not something that could be done in the real world. The other approach would be to show that there is a theory that can be tested in the laboratory that predicts the observed values of the constants of nature.

Suppose, for example, that someone writes down a Theory of Everything (TOE) that explains the entire universe in an equation that can be written on a tee-shirt. This TOE makes many predictions about things that can be seen and observed, and so it can be tested in the usual scientific way. If the theory also predicted the strengths of the fundamental forces, you might be able to argue that you had verified the anthropic principle, even though you had never seen another universe.

The anthropic principle will always be a fascinating subject for debate and philosophical discussion. If it remains untestable, however, it will also always rest outside the realm of science. ☐

James Trefil, the Robinson Professor of Physics at George Mason University, a science commentator for National Public Radio, and a prolific writer, is a member of ASTRONOMY's Editorial Advisory Board.

Entering a New Era

Despite a few anxious moments, the second Hubble servicing mission left the Space Telescope in better shape than ever.

by Richard Talcott

All photos: NASA

Before the space shuttle Discovery roared into the dark skies above Cape Canaveral on the morning of February 11, a few astronomers could be heard grumbling. "Why," they asked, "should we risk the health of an observatory that's performing so spectacularly?"

Their fears, and the worst nightmares of controllers on the ground, came close to materializing before the first spacewalk took place. A gust of air from the shuttle's airlock hit one of Hubble's fragile solar arrays, briefly turning it into a windmill as it rotated from horizontal to vertical and halfway back again. Although the mishap could have severely damaged the observatory, fortunately no harm was done.

If that incident brought home the dangers of servicing Hubble, another illustrated the benefits. During the first three spacewalks, astronauts noted significant wear and tear on parts of HST's thermal insulation. Without some makeshift bandages and an unscheduled fifth spacewalk, key components of the telescope could have been at risk of overheating, which would also seriously damage Hubble. Now with Hubble's new complement of scientific instruments and updated equipment, and a patchwork blanket of thermal insulation, even most skeptics are pleased with the results of the second servicing mission.

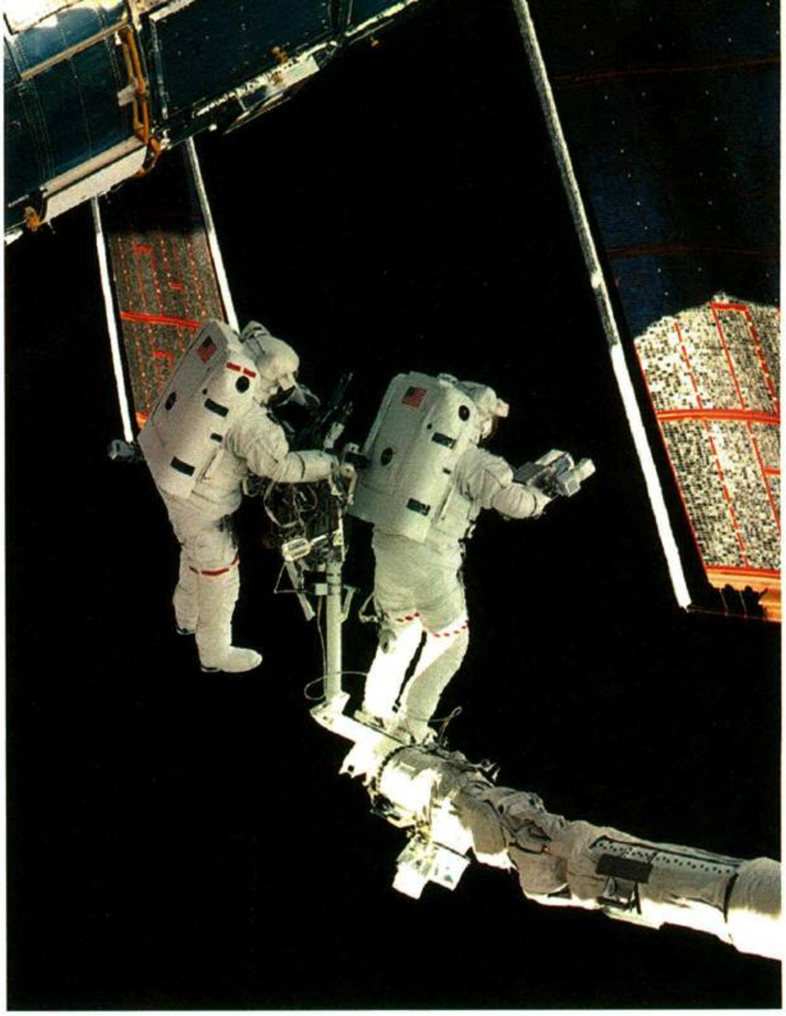
The start of the mission went by the book, offering no signs of the impending excitement. Following the early morning liftoff, mission commander Ken Bowersox and pilot Scott Horowitz slowly closed the gap between Hubble and Discovery, which was making its first trip into space in a year and a half.

By Thursday morning, February 13, the two had steered within 35 feet of the orbiting telescope. Astronaut Steve Hawley, who originally deployed Hubble in April 1990, grabbed the telescope with the shuttle's robotic arm as the two spacecraft flew over the west coast of Mexico. Less than 30 minutes later, Hawley had Hubble firmly in the shuttle's payload bay.

While the crew got ready for the first of four scheduled spacewalks that evening, disaster nearly struck. As Mark Lee and Steve Smith prepared to enter the payload bay, they let the air out of the airlock. But the escaping gas apparently seeped under the shuttle's payload bay and spurted out onto one of the solar arrays. Before the mission, ground controllers hoped to keep the fragile arrays from moving mere inches, but here one of them was swinging several feet. Luckily the arrays proved stronger than many anticipated: tests performed from the ground found no damage.

After this brief scare, Lee and Smith set out on the mission's top priorities: installing two new scientific instruments. They first removed the Goddard High Resolution Spectrograph and replaced it with the Space Telescope Imaging Spectrograph (STIS). STIS can observe in four spectral bands extending from the ultraviolet through the visible into the near infrared, and its two-dimensional detectors will far exceed the capabilities of the linear detectors used in the spectrographs it replaces.

Hubble's solar arrays gleam against Earth's limb after its servicing and prior to its release back into orbit.



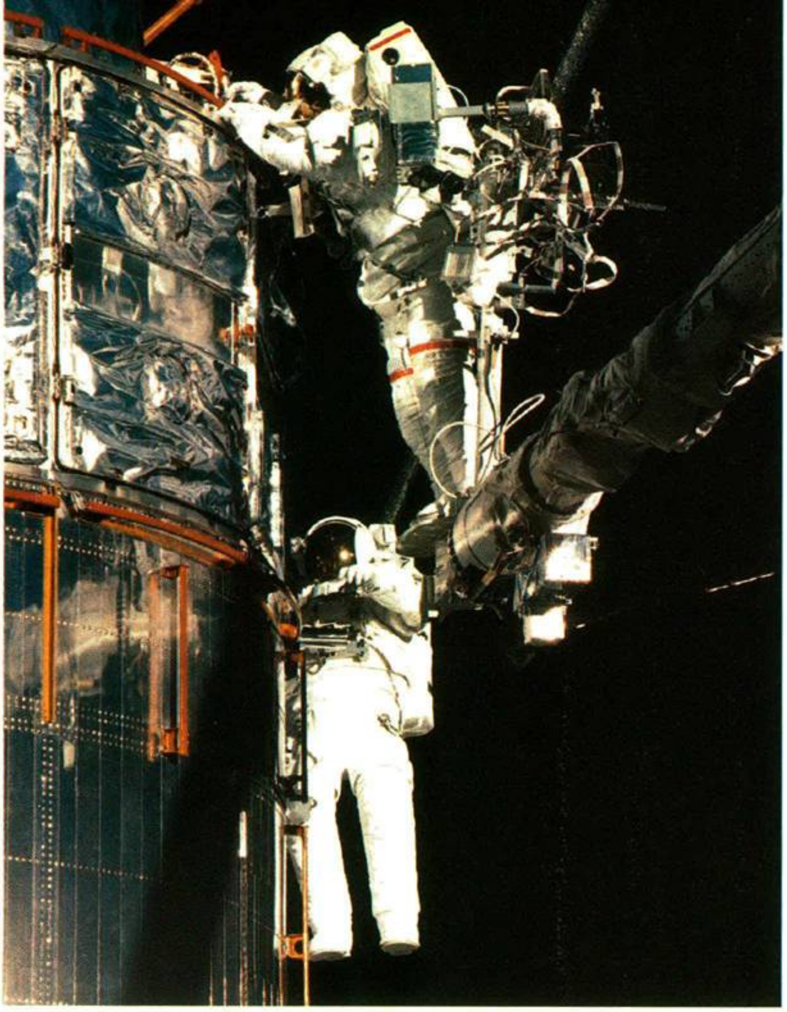
Astronauts Tanner (at right) and Harbaugh survey the solar arrays, looking for any damage resulting from their three years in space.

By separating light into its spectral components, STIS allows astronomers to analyze the composition, temperature, motion, and other properties of celestial objects. Expect new insights into the planets and their moons, the properties of distant galaxies, the dynamics of nearby galactic nuclei, star formation and evolution, and the chemical makeup of the interstellar medium.

After aligning STIS, Lee and Smith removed the Faint Object Spectrograph and installed the Near-Infrared Camera and Multi-Object Spectrometer (NICMOS). Observing at near-infrared wavelengths, NICMOS will see radiation that is largely blocked by water vapor in Earth's atmosphere. This window on the universe will let astronomers probe the dusty cores of active galactic nuclei, image young galaxies in the far reaches of the universe, and examine protoplanetary disks around stars.

It wasn't long into the first spacewalk when the astronauts realized that nearly seven years in space might have exacted a toll on Hubble. While maneuvering around the telescope, Lee and Smith noticed that some of the yellow paint used on HST's handholds rubbed off on their gloves.

On the next night, the second team of spacewalking astronauts — Greg Harbaugh and Joe Tanner — discovered several areas on the telescope where thermal insulation had cracked from exposure to the sun.



On the fifth and final spacewalk, Lee (above) and Smith repair Hubble's damaged insulation with makeshift patches.

On Discovery's middeck, pilot Scott Horowitz fabricates a thermal insulation patch to be installed on an upcoming spacewalk.

Because all the cracks appeared on the side of the telescope that faces the sun, mission controllers worried that, over time, light could penetrate these areas, heating them and damaging key electronic components. The insulation problems didn't prevent Harbaugh and Tanner from finishing their scheduled business: replacing both a degraded Fine Guidance Sensor (used to point the telescope) and a failed mechanical tape recorder, as well as installing new electronics to increase the Fine Guidance Sensor's capability.

Lee and Smith were back outside the next night, replacing a Data Interface Unit that helps manage the flow of information from Hubble, replacing an old reel-to-reel style tape recorder with a Solid State Recorder having ten times the capacity, and changing one of the Reaction Control Wheel Assembly units used to move the telescope toward a target.

Harbaugh and Tanner began the fourth spacewalk by finishing the previously scheduled maintenance: replacing a Solar Array Drive Electronics package that positions the arrays and putting protective covers over the telescope's magnetometers, which help orient Hubble with respect to Earth's magnetic field. They then began repairing the insulation. Using material sent along to patch hits from micrometeorites, the astronauts placed new thermal blankets over the degraded insulation around the light shield at the top of the telescope.

While Harbaugh and Tanner worked in the payload bay, Horowitz and Lee were inside Discovery fabricating four more thermal blankets from thin strips of backup insulation. On the fifth and final spacewalk the next night, Lee and Smith installed them over three equipment bays located near the middle of the telescope.

In all, the astronauts spent 33 hours and 11 minutes outside, two hours shy of the record set during the first servicing mission in 1993. They installed two powerful new instruments, updated Hubble's technology from the 1970s to the 1990s, and repaired damaged insulation that could have threatened the telescope's future. They also boosted Hubble's orbit by about 9 miles, placing it higher than ever before where drag from Earth's outer atmosphere will be reduced.

The fruit of the astronauts' labors won't be seen for a while. Although all the instruments and systems checked out after the mission, the first observations from STIS and NICMOS likely won't come until early May. So keep your eyes peeled to the pages of ASTRONOMY — the best may well be yet to come. ☐

Discovery's seven-man crew poses inside the shuttle as Hubble lurks in the background through the windows.

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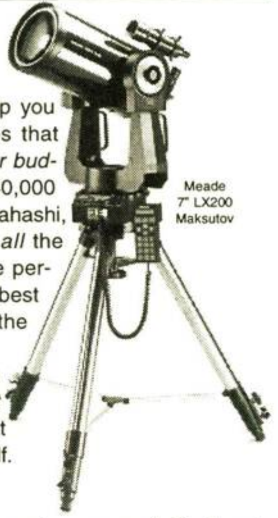
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WRITE NO. 75 ON THE READER SERVICE CARD

SKY ALMANAC

Venus twinkles brilliantly in the west as Mars loses still more of its post-opposition luster. Look overhead when the Red Planet makes a temporary asterism with Arcturus and Spica.

Text by Martin Ratcliffe

Activity boxes by Rick Shaffer

If you're out in the backyard preparing an evening barbecue, or taking a road trip this summer, remember to take along a pair of binoculars. Star clouds, globular clusters, our Milky Way galaxy and the occasional planet will be waiting patiently for you to capture their photons. And let's not forget our nearest neighbor, the moon. Many folks are surprised to learn that numerous craters are visible by viewing the moon through a small pair of binoculars.

It is unlikely that anyone except a few observers armed with binoculars will manage a final glimpse of **Comet Hale-Bopp**. It passes northeast of Betelgeuse during the first week of June.

For observers in Miami, Florida, the comet sets 50 minutes after the sun. In Houston, Texas, Hale-Bopp sets 40 minutes after sundown, and in San Diego, California, the comet slips below the horizon a mere 30 minutes after the sun. For would-be observers farther north, Hale-Bopp is lost in bright twilight, its spectacular form during the last few months just a memory.

As the solar illumination ebbs away from the western horizon, look to the west-northwest for a rapidly setting **Venus**. It stands 10° to 15° above the horizon at sunset and sets within the hour.

Once it's gone, turn to the east to find the soft glow of the Milky Way rising. Lying in its midst are three brilliant stars that pop out of the darkening blue sky soon after sunset.

Deneb, Vega, and Altair are a famous trio, forming a giant figure in the sky called the Summer Triangle. Seven other 1st-magnitude stars also appear on the early-evening sky stage. Gemini's Castor and Pollux, low in the west, set soon after the sun. Capella, in Auriga the Charioteer, sets soon afterwards north of the Twins. Pursuing them all from the southwest is Regulus, in Leo the Lion, and Spica, in Virgo the Virgin, still high in the south. The deep orange heart-star of Scorpius the Scorpion, Antares, twinkles from its ascending vantage point in the south-southeast. Look high above your head for the yellowish dusky-colored star, Arcturus, the brightest star in the June sky and the standard bearer of Bootes the Herdsman.

Arcturus seemingly has a twin in this month's sky — **Mars**. This reddish planet glows all month from Virgo, high above the south-southwestern horizon after sunset. Its tiny disk shrinks from 9" to 8" and fades to magnitude 0.6 by June 30. This makes it difficult to detect features on its surface through a telescope.

On June 12 use a scope to witness Mars's easterly path take it to within 8' of magnitude-3.6 Porrima (Beta [β] Virginis). On the next night Mars gets brushed by a first quarter moon that skims within 21' of the Red Planet. Observers in southwest Africa and Madagascar will see an occultation of Mars by the moon.

Connect Mars with Arcturus and 1st-magnitude Spica in Virgo to get a temporary "Late-Spring Triangle" high in the southwest,

Alan Dyer

Watch for the spine of our home galaxy, the Milky Way, as it billows from the south and flows far overhead. The dark band is dust along our line of sight as we view the galaxy edge-on. The Summer Triangle of Vega, Deneb, and Altair passes overhead.

1997
JUNE

3 The moon passes 1.6° south of Mercury, 9 a.m. EDT

5 New moon is at 3:03 a.m. EDT

6 The moon passes 6° south of Venus, 1 p.m. EDT (page 67)

10 Jupiter is stationary, 7 a.m. EDT

12 The moon is at apogee (251,149 miles from Earth), 1:06 a.m. EDT

13 First quarter moon is at 12:51 a.m. EDT
The moon passes 0.3° south of Mars, noon EDT (page 68)

14 Mercury passes 5° north of Aldebaran, 10 a.m. EDT

17 Asteroid Eunomia is at opposition, 7 a.m. EDT

20 Full moon is at 3:09 p.m. EDT

21 Summer solstice is at 4:20 a.m. EDT

22 The moon passes 4° north of Neptune, 6 p.m. EDT

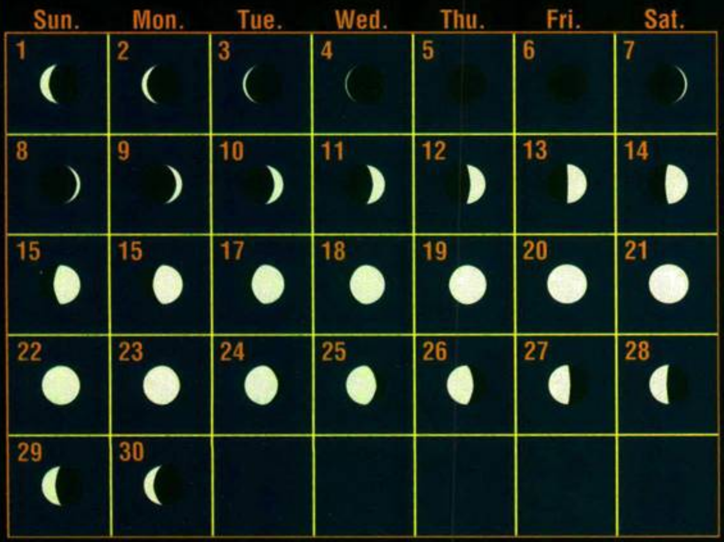
23 The moon passes 4° north of Uranus, 9 a.m. EDT
Venus passes 5° south of Pollux, 7 p.m. EDT

24 The moon is at perigee (227,729 miles from Earth), 1:00 a.m. EDT
The moon passes 4° north of Jupiter, 8 a.m. EDT (page 68)

25 Mercury is in superior conjunction, 3 p.m. EDT

27 Last quarter moon is at 8:42 a.m. EDT

28 The moon passes 0.2° north of Saturn, 8 a.m. EDT (page 68)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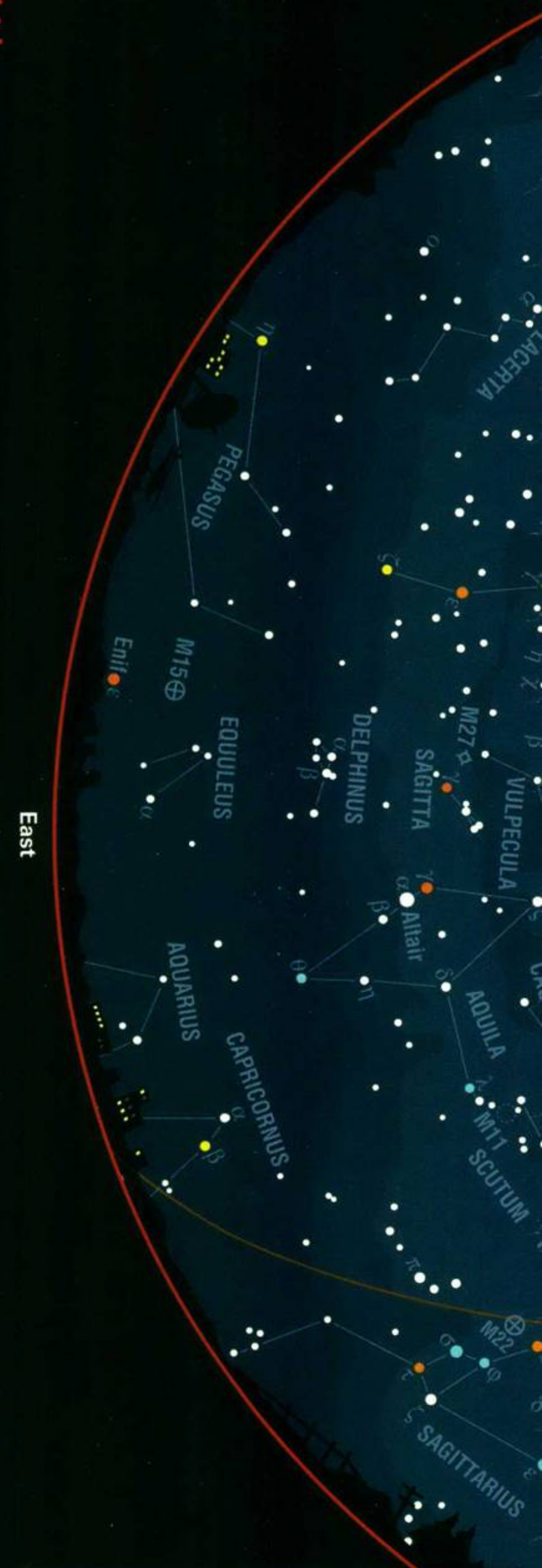
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EQUULEUS
DELPHINUS
SAGITTA
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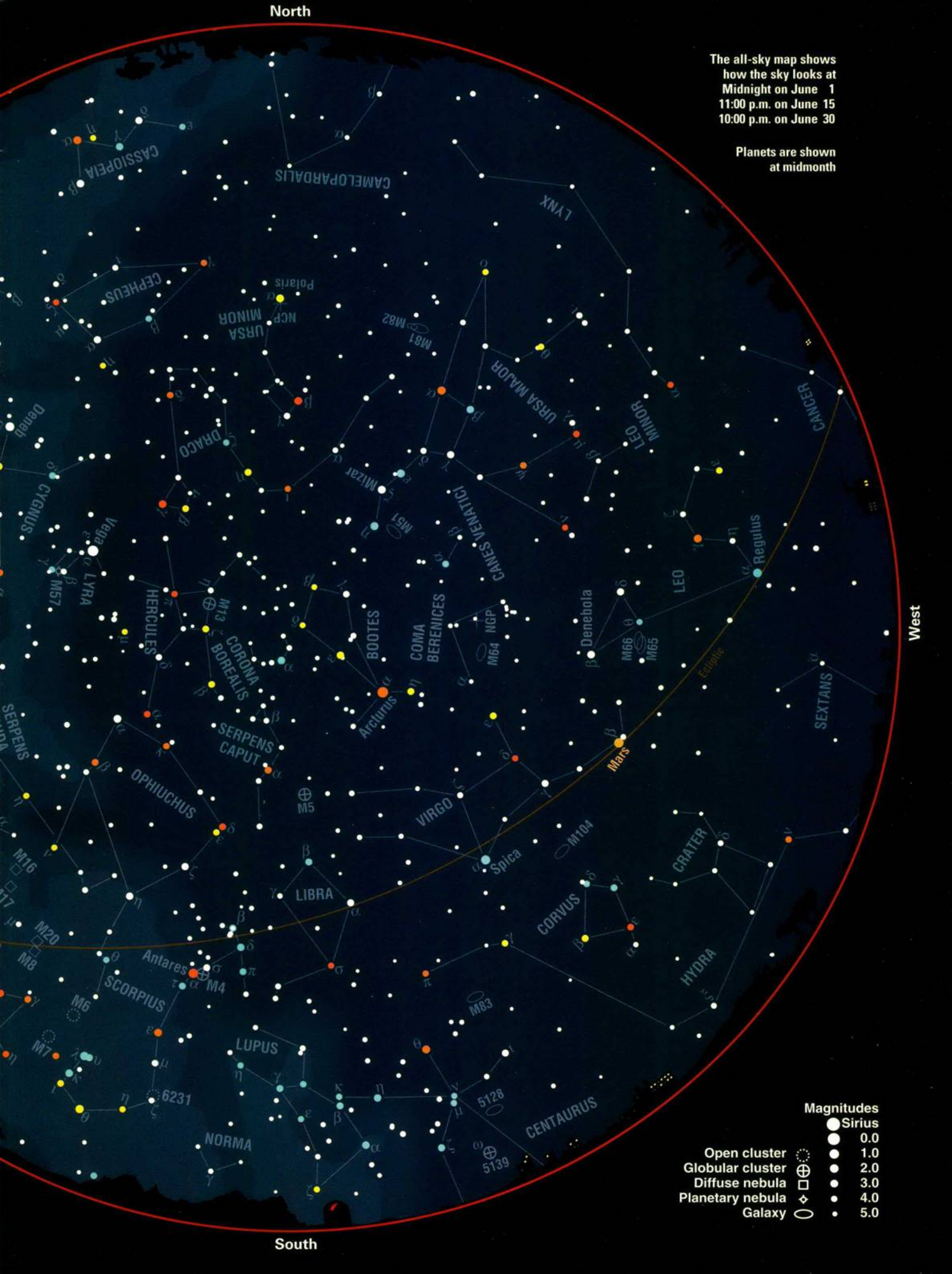
VULPECULA
Altair
AQUILA
AQUARIUS
CAPRICORNUS
M11
SCUTUM
M22
SAGITTARIUS

This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.



North
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CAMELOPARDALIS
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CEPHEUS
Polaris
NCP
URSA MINOR
M82
M81
URSA MAJOR
LEO MINOR
CANCER
Deneb
DRACO
CYGNUS
Mizar
M51
CANES VENATICI
Vega
LYRA
M57
HERCULES
M13
CORONA BOREALIS
BOOTES
COMA BERENICES
NGP
M64
Denebola
M66
M65
LEO
Regulus
Ecliptic
SEXTANS
Arcturus
SERPENS CAPUT
SERPENS
Mars
OPHIUCHUS
M5
VIRGO
M104
CRATER
Spica
LIBRA
CORVUS
M16
M17
M20
M8
Antares
M4
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5128
CENTAURUS
NORMA
5139
Magnitudes
Sirius
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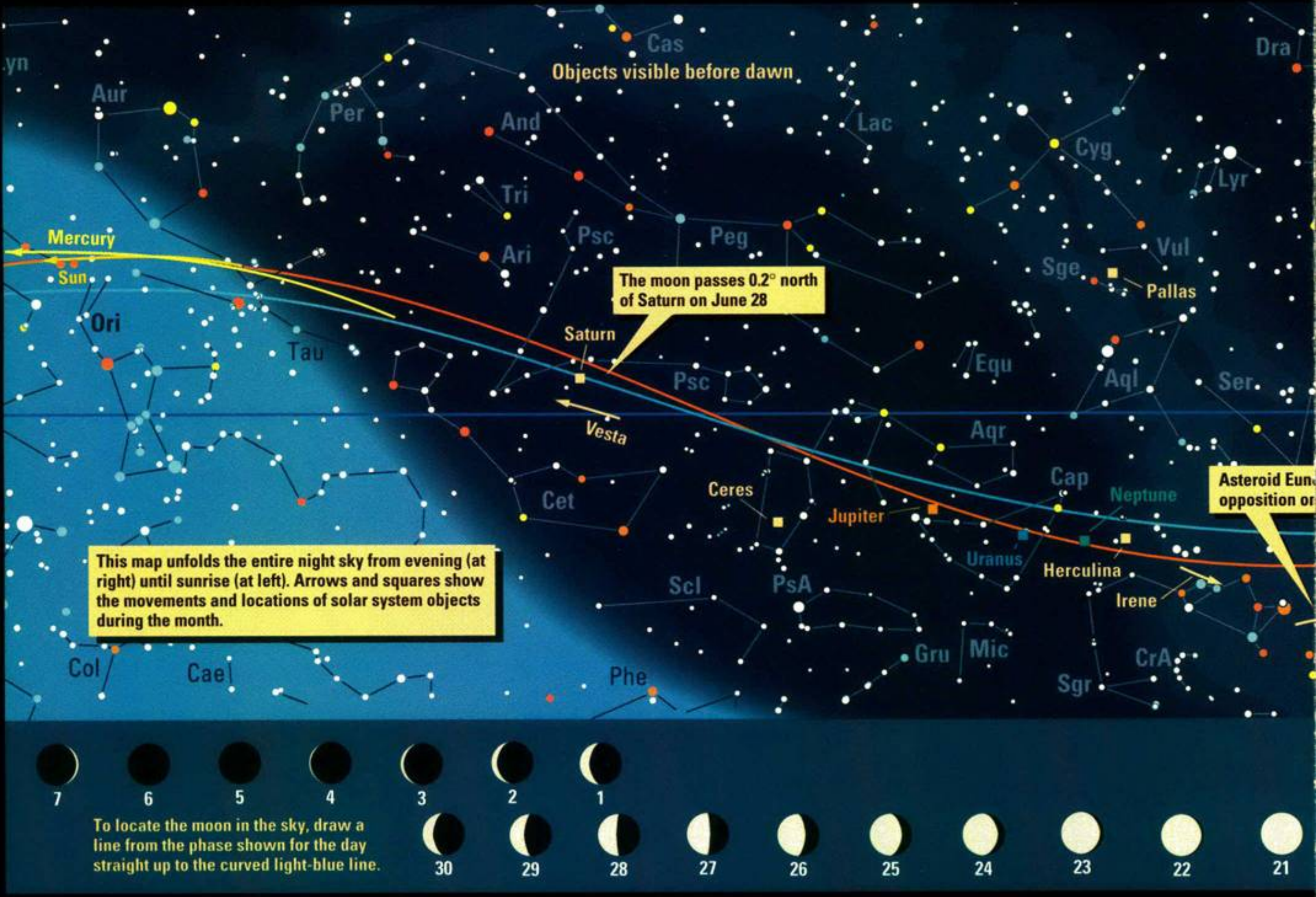
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

The all-sky map shows
how the sky looks at
Midnight on June 1
11:00 p.m. on June 15
10:00 p.m. on June 30

Planets are shown
at midmonth

THE PATH OF THE PLANETS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Objects visible before dawn

The moon passes 0.2° north of Saturn on June 28

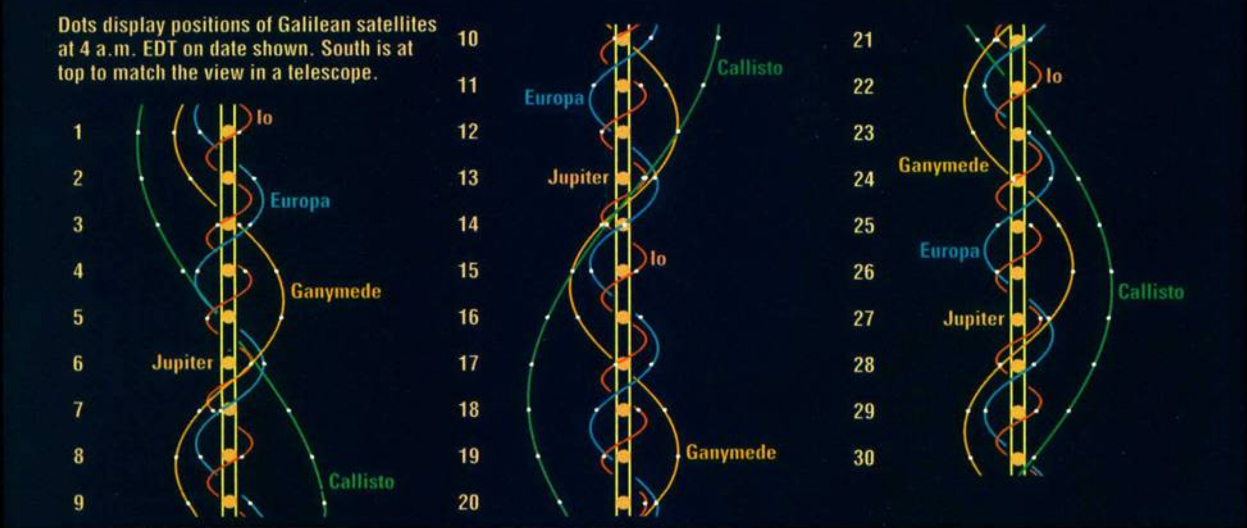
This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.

Asteroid Eun
opposition or

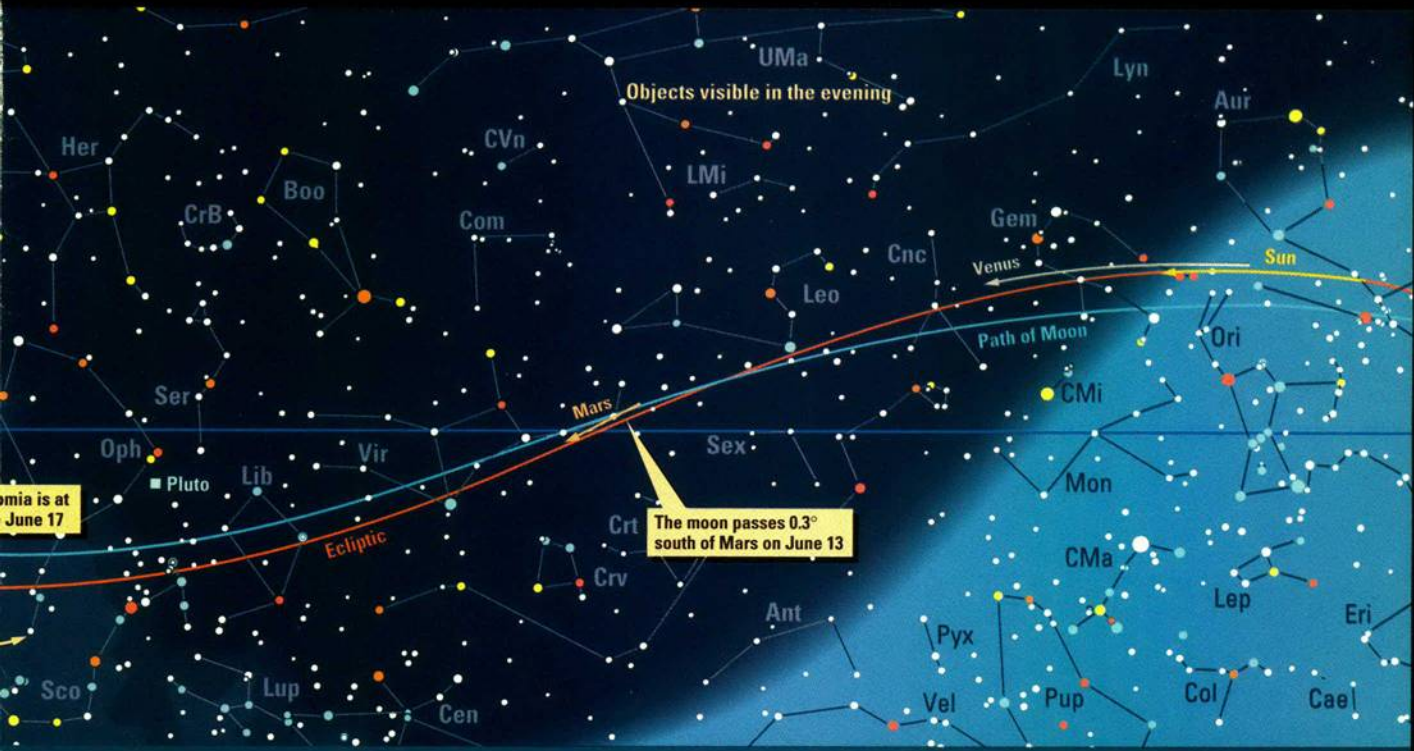
To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPI
Date	June 1	June 15	June 15	June 15	June
Magnitude	0.0	–1.1	–3.9	0.4	–2
Angular Size	6.9"	5.5"	10.5"	8.2"	44.
Illumination	56%	87%	94%	88%	99
Distance (AU) from Earth	0.981	1.230	1.593	1.137	4.4
Distance (AU) from Sun	0.404	0.327	0.718	1.580	5.0
Right Ascension (2000.0)	3h03.4m	4h39.4m	6h58.2m	11h54.2m	21h3
Declination (2000.0)	14°18'	21°30'	24°01'	1°11'	–14

JUPITER'S MOONS



Dots display positions of Galilean satellites at 4 a.m. EDT on date shown. South is at top to match the view in a telescope.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Sex
Vir
Mon
Pluto
Lib
Crt
Ecliptic
CMa
Crv
Lep
Ant
Eri
Pyx
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Lup
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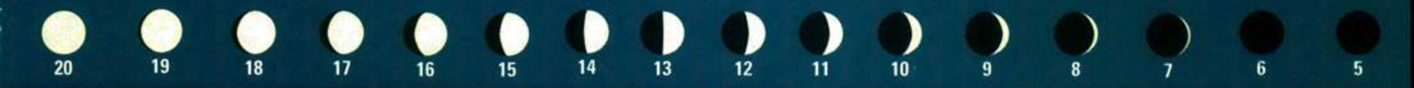
Objects visible in the evening

omia is at
June 17

The moon passes 0.3° south of Mars on June 13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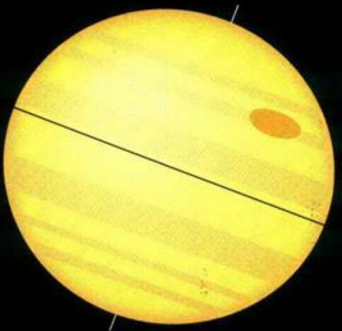
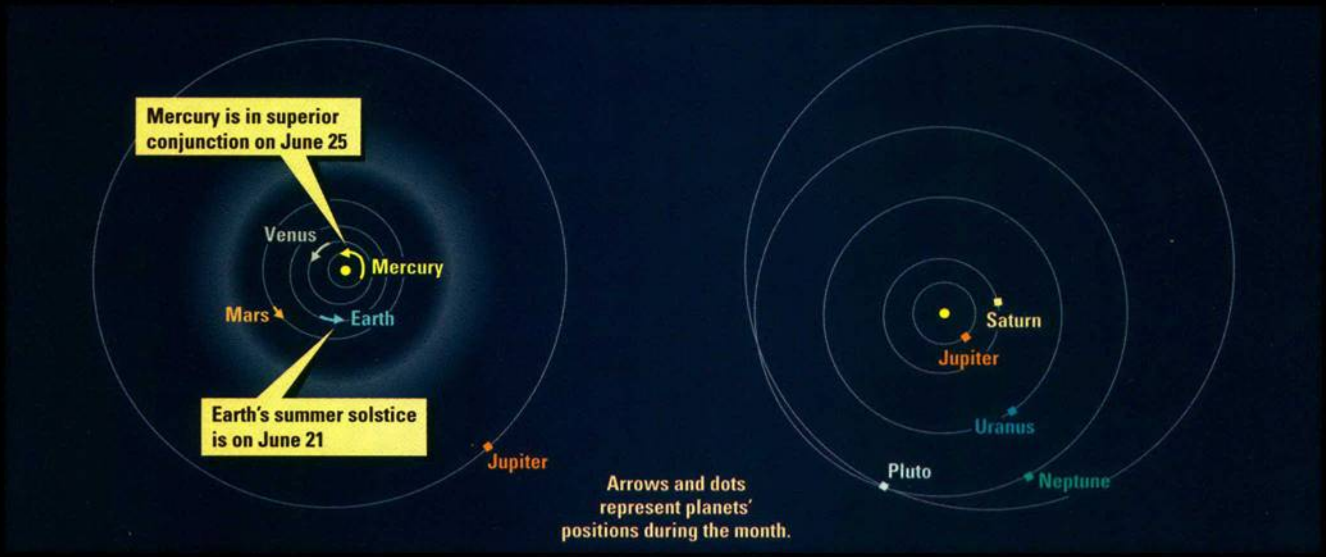


TER	SATURN	URANUS	NEPTUNE	PLUTO
15	June 15	June 15	June 15	June 15
6	0.6	5.7	7.9	13.7
"	17.0"	3.7"	2.3"	0.1"
%	100%	100%	100%	100%
58	9.799	19.079	29.319	29.052
31	9.423	19.819	30.151	29.984
.3m	1h12.0m	20h43.5m	20h06.3m	16h16.6m
56'	5°05'	–18°48'	–19°51'	–8°13'

THE PLANETS IN THEIR ORBITS


Venus
Mercury
Mars
Earth
Jupiter
Saturn
Jupiter
Uranus
Pluto
Neptune

Mercury is in superior conjunction on June 25

Earth's summer solstice is on June 21

Arrows and dots represent planets' positions during the month.

which competes for attention with the Summer Triangle still rising in the east.

Vega is the brightest star in the Summer Triangle and fifth brightest in the whole heavens. Its name comes from the Arabic "Al Nasr al Waki," the swooping eagle, where on medieval charts the constellation is portrayed as an eagle bearing a harp in its beak. Today the constellation to which Vega belongs is Lyra the Harp, from the Greek "kithara."

Vega lies 27 light-years from Earth. It's a blue-giant star three times the diameter of our sun, one of a few stars to have had its diameter measured directly. It also shines 58 times brighter than the Sun.

Vega was also the first star to be photographed, at Harvard College Observatory in 1850. In another first, in 1983 the Infrared Astronomical Satellite, IRAS, discovered a shell of dust surrounding Vega, evidence of a primordial disk of material similar to those found around stars in the Orion Nebula by the Hubble Space Telescope.

NASA's Space Infrared Telescope Facility, SIRTF, currently scheduled for launch in 2002, will pack enough resolution to image the disk directly and perhaps determine if there are any planets orbiting the star.

As it is, our planetary system is heading in the general direction of Vega at 12 miles per second. We'll arrive there in under half a million years, by which time of course, Vega will have moved from its current position.

By midnight Vega stands almost overhead. Adjacent to its home constellation of Lyra is Hercules, the fifth largest constellation in the sky. Once you've scanned the Milky Way with your binoculars, move to this dimmer region of the sky.

The legendary strongman contains no stars brighter than 3rd magnitude, but plays host to one of the sky's most popular deep-sky objects.

It's the globular star cluster M13, shining across 24,000 light-years. Spotting M13, the most observed globular cluster in the Northern Hemisphere, is easy. It lies a third of the way between Eta (η) and Zeta (ζ) Herculis, two stars that mark the western side of the keystone-shaped central part of Hercules's torso.

The cluster glows at magnitude 5.9, just barely visible to the unaided eye and easily seen in any binoculars as a fuzzy patch of light. A telescope reveals a splash of stars 100 light-years across. At least one million stars congregate together in this space to create this object that also comes with the popular moniker of "the Hercules Cluster."

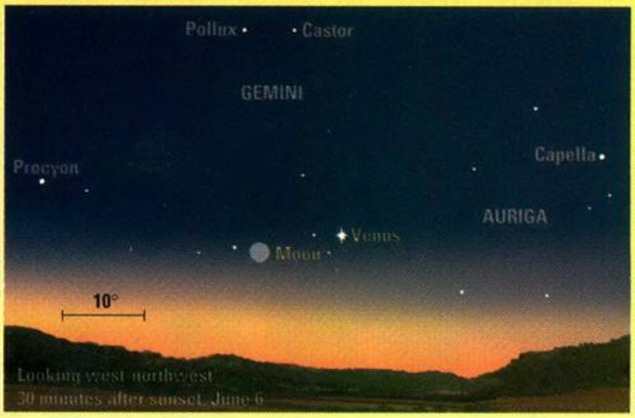
If you're using at least a 6-inch scope under dark skies, pan 40' northeast of M13 to pick up the tiny 11th-magnitude spiral galaxy NGC 6207.

Hercules holds another interesting sight. Alpha (α) Herculis, or Rasalgethi, one of the most luminous irregular variables in the sky and one of the largest known red giant stars.

Rasalgethi spans a staggering 400 times the diameter of the sun, so huge that if placed at the center of our solar system, its atmosphere would extend out beyond the orbit of Mars and into the asteroid belt. Its variability was first detected by Sir William Herschel in 1795 to range between magnitudes 3.1 and 3.9 over a period of 90 days.

The name Rasalgethi comes from an ancient Arabic phrase that means "head of the kneeler." This makes sense when you consider that Northern

The Moon and Venus Set Together



All illustrations by ASTRONOMY: Thersa Meztger

Every time the moon and Venus set together affords a perfect photo opportunity to frame the extraterrestrial with something terrestrial like a tree, house, or scenic skyline. This month offers just such a chance on the 6th, beginning a half hour after sunset. Use binoculars to find magnitude –3.9 Venus slightly to the right of where the sun set. Even though the moon is much brighter at magnitude –9.3, its light spreads over a much larger area of the sky than that of Venus, so it'll be harder to spot.

Look nearby for a 2-day-old moon just 7½° to the right of Venus. You shouldn't have much trouble finding the pair as the sky darkens. At 40 minutes after sunset, Venus will be 6½° above the horizon, while the moon will lie a degree lower.

Capture this conjunction by mounting a 35mm camera to a tripod. Load the camera with fast film — I've had good results with Kodak's new Royal Gold 1000 — and set the aperture one or two stops in from wide open. Focus the lens to infinity. Try framing the scene with a nice tree, steeple, or skyscraper . . . whatever's handy. Then expose the film for 1, 2, 4, 8, and 16 seconds. If you're new at this kind of photography, try shooting some test exposures on Venus a few nights before, and then take your film to a one-hour developer to find out what combination of exposure and aperture works best.

Russell Beatty

Hemisphere observers see Hercules hanging upside-down, and indeed kneeling over the winding form of Draco the Dragon.

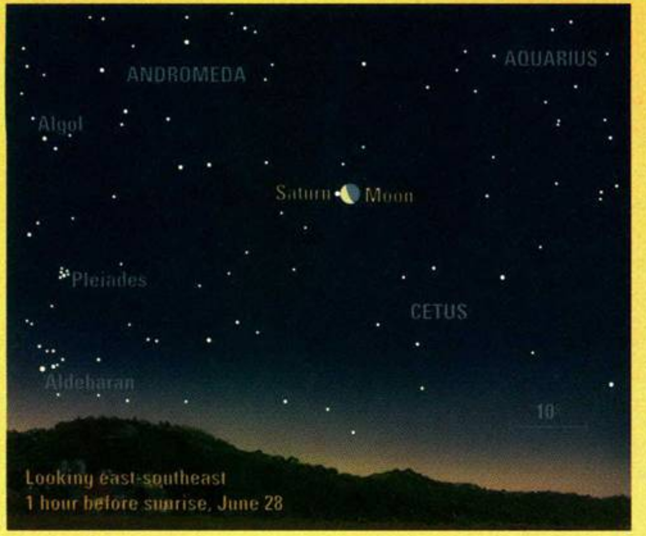
Known to the Greeks as Engonasis, the Kneeling One, Hercules is also associated with Izhdubar, the Sun God, a link that perhaps explains the origin of the 12 labors of Heracles, the Greek equivalent of Hercules. Heracles's 12 labors link the sun's passage through 12 constellations along the ecliptic.

This month the sun labors on this path through Taurus the Bull, on its way toward Gemini. It reaches its most northerly point above the celestial equator at 4:19 a.m. EDT on June 21. This moment marks the arrival of the summer, solstice, when the days are longest and nights are shortest for people living north of the equator.

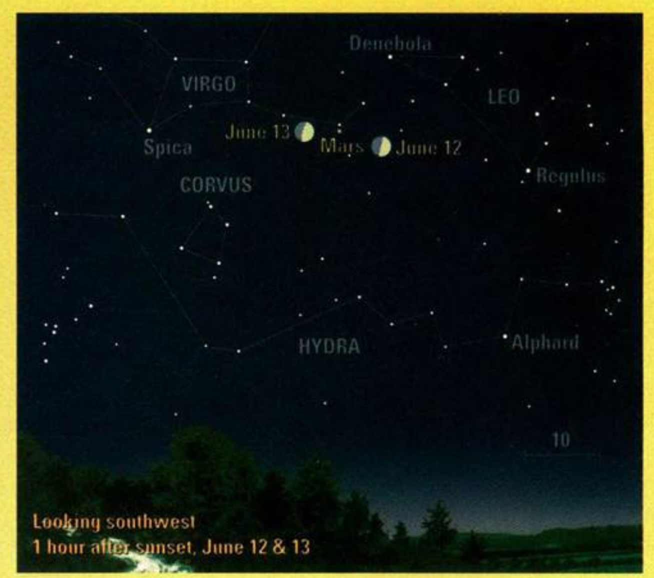
The short nights mean late sunsets, and one has to wait until quite late in the evening for dark skies.

Pluto is best seen around local midnight when the sky is darkest. A good opportunity to spot Pluto comes during the last week of June. The planet lies in a relatively sparse star field less than 15' north of magnitude-7.1 18 Ophiuchi. Distant Pluto spends the month in Ophiuchus the Serpent Bearer, and glows dimly at magnitude 13.7.

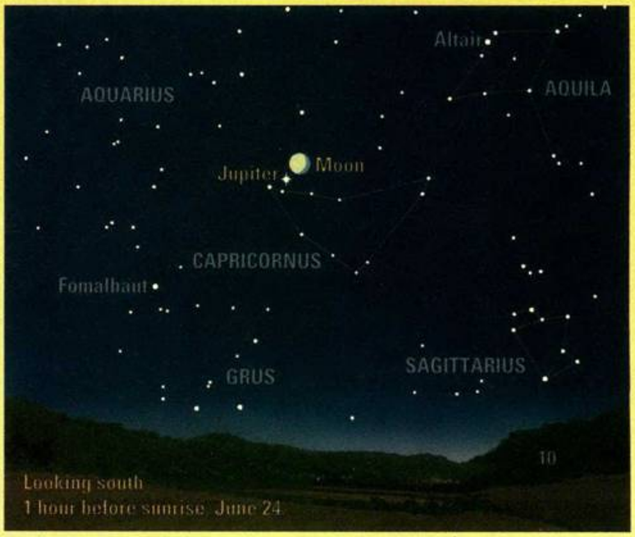
Luna Continues Her Tour



Looking east-southeast
1 hour before sunrise, June 28



Looking southwest
1 hour after sunset, June 12 & 13



Looking south
1 hour before sunrise, June 24

After visiting Venus on June 6, the moon continues a tour of the night sky, passing various objects of interest along the way. It begins by gliding a little more than 5° west of dusky Mars on June 12. The next evening, the moon moves to a position a little less than 5° east of the Red Planet. Since opposition this past winter, Mars's disk has shrunk to less than 9" while diminishing in brightness to magnitude 0.2.

Far to the east, look for brilliant white Jupiter. If you've not seen Jupiter since last autumn, its location in eastern Capricornus may surprise you. Jupiter's 12-year orbit around the sun means that it covers 30° of sky each year. On average, that's a new constellation of the zodiac every year. On the morning of June 24, look for the moon and Jupiter high in the southern sky an hour before sunrise.

Four days later, another member of our solar system's family of gas-giant planets gets a lunar encounter. On June 28, the 23-day-old moon passes less than half a degree south of Saturn. Your view through a scope should reveal Saturn's glorious ring system and Titan, a planet-sized satellite.

Titan is the only moon in our entire solar system massive enough to retain an atmosphere. Some scientists think its thick atmosphere might even harbor life.

At the other extreme, our smaller moon is a sterile, airless place. But its tidal influence provided a fundamental ingredient for life here on Earth. Undoubtedly, tidal pools were a valuable beachhead as the first sea-dwellers struggled onto land. Speaking of seas, Titan's surface might be covered in an ocean of liquid methane.

Get to Know Spica

Tim Puckett

Virgo the Virgin's bright star Spica, one of only 20 1st-magnitude stars in the sky, twinkles high in the west on June evenings. But one characteristic makes it shine among equals: its magnitude is precisely 1.0. Spica also has a companion star whose presence is only revealed when astronomers break the star's light into a rainbow of colors.

In 1890, regular variations in Spica's spectrum allowed H. C. Vogel to deduce Spica B's remarkably short orbital period of only 4.2 days. Further studies revealed that Spica was 11 times our sun's mass, with 8 times the diameter. Spica's luminosity of 2,300 times the sun makes it bright in our night sky despite the star's 250 light-year distance. We also know that Spica B weighs in at 6.8 solar masses at 4 solar diameters.

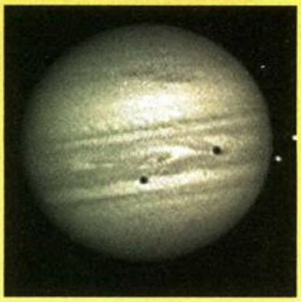
Spica A and B travel around one another in a slightly eccentric orbit 11 million miles apart. The orbit is only inclined approximately 24° to our line of sight, which means B slightly eclipses A once each orbit. It's not much of an eclipse, though, as the dip in their collective brightness amounts to only 0.07-magnitude. Spica A itself varies in brightness once every 4.2 hours.

Before you contemplate writing a science fiction story about life on a planet orbiting the spican system, remember that stars this massive burn their nuclear fuel at a prodigious rate. They won't be around long enough for life to evolve around them.

The story of how Spica got its name may be more interesting than any sci-fi story. Depending upon which ancient civilization you refer to, she represents various goddesses, such as Isis in Egypt or Persephone in the Classical World. In other versions, Spica is a spear of wheat being held by a reclining virgin.

The logic of this mostly escapes me, for much the same reason I fail to see a reclining virgin in Virgo's pattern of stars. It's certainly possible the ancients associated Spica's cool blue-white color with the purity of virginity. It's also not much of a stretch to associate Spica with wheat, as it's best seen in the evening sky during spring, just in time for the planting season.

Jupiter's Winking Moons



Gregory Terrance

Every six years, or twice in Jupiter's 12-year orbit, the Earth and sun pass through the orbital plane of Jupiter's four brightest satellites. This orientation makes them pass in front of and cast shadows upon one another. Astronomers coin this phenomenon a "mutual event."

There are two types of mutual events: occultations and eclipses. An occultation occurs when one satellite passes between the Earth and another satellite, either partially or totally obscuring it from our view.

Eclipses can be total or partial. A total eclipse happens when a satellite passes completely into the umbra, or center portion, of another satellite's shadow. The geometry must be just right for us to witness this type of mutual event.

Typically, a satellite's brightness doesn't change more than a magnitude during any eclipse. If you have a photometer, try taking regular measurements of an eclipsed satellite's brightness to make a light curve. Do your results conform to the predictions?

EVENTS OF THE GALILEAN SATELLITES

Date	Event	Type of Event	Begins (EDT)	Ends (EDT)	Light Loss	Distance (Jupiter radii)
June 6	Ganymede occults Io	Total	2:22 a.m.	2:36 a.m.	32%	5.8
June 12	Io eclipses Europa	Partial	1:40 a.m.	1:43 a.m.	78%	6.0
June 14	Ganymede occults Io	Partial	3:42 a.m.	3:52 a.m.	32%	5.6
June 19	Io eclipses Europa	Partial	3:56 a.m.	4:00 a.m.	58%	6.1
June 20	Ganymede occults Europa	Partial	4:32 a.m.	4:40 a.m.	12%	8.4
June 30	Callisto eclipses Europa	Partial	1:36 a.m.	1:45 a.m.	55%	2.4

You'll also have to wait until midnight to catch **Uranus** and **Neptune**, two far-off planets that continue their crawl along the Sagittarius/Capricornus border. Both are moving in a retrograde, or westerly, direction against the background stars as they approach opposition dates in July.

Neptune rises by 10 p.m. local time toward the end of June, reaching magnitude 7.8 as it crosses back into Sagittarius after a two-month sojourn in Capricornus. At a little less than 30 AU (an astronomical unit is 93 million miles) from Earth, all that Neptune can muster in apparent size is 2". Its true diameter spans four times that of Earth.

Uranus is about the same size as Neptune, but 10 AU closer to Earth. Uranus rises 30 or so minutes after Neptune, managing a 3.7" diameter and a brightness of magnitude 5.7. This means it's visible to the naked eye under a dark sky. Uranus lies almost due east of 6th-magnitude Omicron (o) Capricorni; and is an easy object to spot with binoculars.

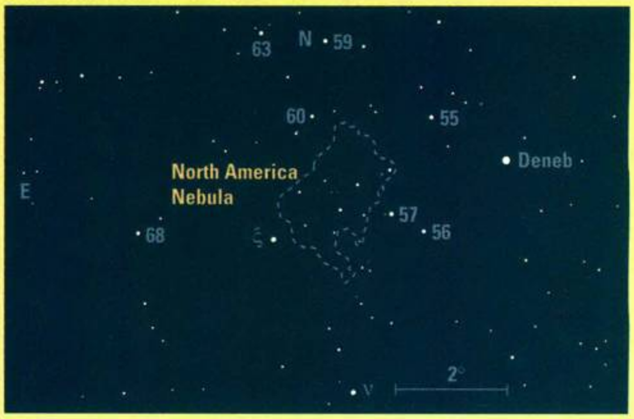
Jupiter joins its gas-giant cousins 30 minutes after Uranus rises. It lies on the eastern side of Capricornus, rising in the southeast after midnight on June 1 and an hour before local midnight on June 30. Jupiter reflects enough sunlight to shine at magnitude –2.6 by the end of June.

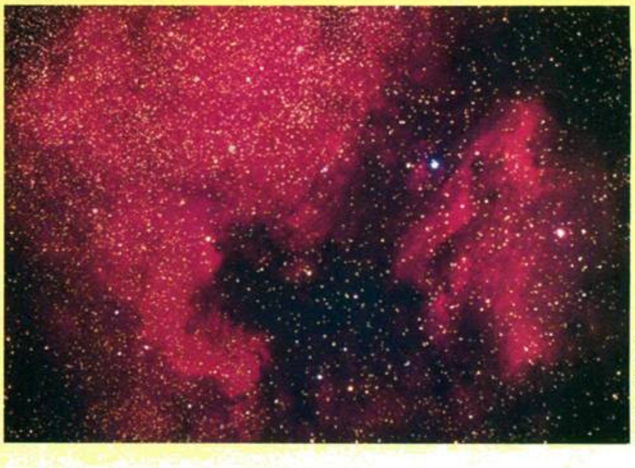
Jupiter's easterly track among the stars comes to a halt a couple of degrees north of Gamma (γ) Capricorni on June 10. The giant planet will spend the coming four months moving retrograde, or westward, toward the central region of Capricornus.

Jupiter's opposition occurs in August, but already the disk of the planet is only 3" shy of its maximum apparent size of 48.6". Only the moon outshines Jupiter in the predawn sky, and does so easily as it glides 3.5° north of Jupiter on June 24.

The last of this month's

Observer's Challenge:
The North America Nebula




Michael Stecker

For years, conventional wisdom has said that large, dim, extended nebulous objects such as the North America Nebula, NGC 7000, could only be glimpsed by experienced observers from dark observing sites on the best nights of the year.

That wisdom was certainly conventional, but it no longer applies for a variety of reasons.

First, coatings on optics have improved over the years, so there's less stray light bouncing around in instruments. This increases contrast.

Second, our population has moved south and especially west, to regions of North America where the average humidity is much lower than back east. This means that more observing locales have much less water vapor in the air to scatter light and reduce contrast.

Third, our population is more mobile than it was even a generation ago. We think nothing of driving 100 miles to get under really dark skies. (When I was in high school, driving 15 miles south of Dallas, Texas was a major expedition.)

So in theory, seeing the North America Nebula isn't hard. First, familiarize yourself with this box's map. Pay particular attention to the nebula's size — it's a bit less than 2° across. I'm emphasizing this because I've shown the North America to many first-time observers. The universal reaction is, "I was expecting something a lot smaller! "

Next, give your telescope a rest for a little while. Recline in a chaise lounge with your binoculars and look just a bit west of Deneb. Keep the bright star out of your field, as it tends to overwhelm the much-dimmer North America.

Double check your orientation; the nebula's Mexico and the Yucatan are to the south. The Gulf of Mexico lies at the same declination as the bright star 62 Cygni, and is almost exactly halfway between 62 and 56 Cygni. It's likely you'll spot the Gulf of Mexico first with averted vision, or by looking at the object "out of the corner of your eye." After a while, you'll see more than just the Gulf.

Now put the binoculars down and position your chaise lounge so that the edge of a roof, a tree limb, or telephone pole obscures the glare of magnitude-1.25 Deneb. Can you see the North America Nebula with your naked eye as a colorless blob of light?

First Views:
A Galaxy's Extended Family

Globular clusters have long been regarded as the "old ones" of any galaxy, lingering star clusters that formed during an initial wave of star formation. The age of these stars is a big issue, for some astrophysicists believe they have found globular clusters to be as old as 15 billion years.

"So what," you may well ask.

Well, other groups have pegged the universe's age to be between 8 and 11 billion years. What kind of universe has constituents older than the universe itself? The real answer may be that one or both of the age measurements is incorrect. The discrepancy has led to a spirited debate.

But most astronomers have a good idea of how a globular formed in the first place. Some who study the formation and interaction of galaxies have suggested that some globulars were formed in the turbulent wake of galactic collisions, and that their numbers and distribution around a galaxy could be tracers to a galaxy's past.

Regardless of their possibly turbulent past, globular clusters are among the most breathtaking objects to view in all but the smallest telescopes. Start with your lowest power and admire the general details of the cluster. Do you see any star chains? If the seeing is steady, bump up the power until the view starts degrading.

Begin a globular tour by looking at M13, the Hercules Cluster, in the keystone of Hercules. This cluster shines at magnitude 5.9, which allows it to be seen with the naked eye from a dark site. It's about 24,000 light-years distant from us, and the brightest of its one million stars shines at magnitude 11.9. We see a thousand-or-so of its red-giant-type stars as yellowish because our eyes aren't very sensitive to red light.

Moving south, M4 can be found easily in Scorpius lying a bit over a degree west of Antares. M4 is actually a lot closer than M13. It's only about 6,000 light-years away, but the large amount of gas and dust between us and M4 squelches its total magnitude down to 5.9. Were it not for the intervening material, it would be at least a magnitude brighter.

You'll notice that M4 is a lot less concentrated than M13. That's true, but it also looks looser because it doesn't have nearly as many red giant stars near its core as M13.

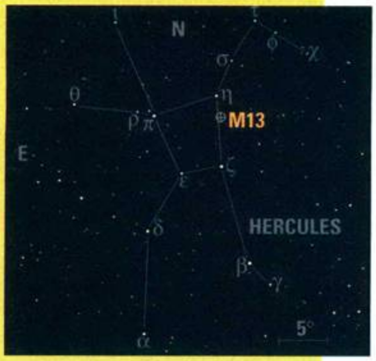
Moving to Sagittarius the Archer, we come across M22. It's brighter than M13 and, at only 10,000 light-years away, is quite a bit bigger in angular size than its cousin in Hercules.

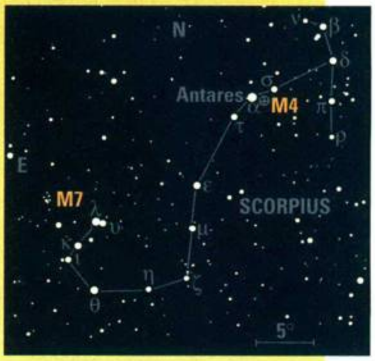
But M22 always seems left out of everyone's list of great globular clusters due to its southerly location. M13, on the other hand, is much farther north in the sky and easily observed for much of the year.

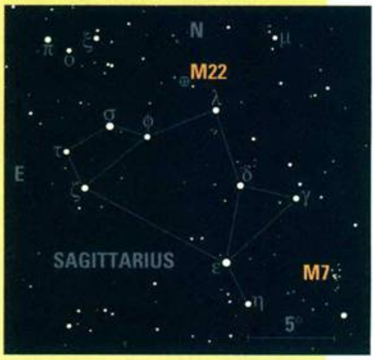
So take a glance at the Archer's M22 as it culminates on these June evenings. And remember, there are a lot more globulars up and down the summer Milky Way. They're all worth a look.

Tony and Daphne Hallas

Mace Hooley







Carl Weber

gas-giant planets, **Saturn**, rises in Pisces at 3:30 a.m. local time on June 1 for observers near 40° north latitude. By June 30 it climbs the east rise two hours earlier. Its magnitude-0 brightness is greater than that of Antares, visible in the southwest.

The Ringed Planet's position is given away this month twice by a last quarter moon when it passes 0.5° northwest of Saturn on June 1 and less than 0.2° north of Saturn during the early morning hours of June 28.

For the June 28 event, observers in Florida should be able to watch the ringed planet disappear behind the moon after sunrise. The next such event visible for most of the United States will occur on September 18.

Glimpsing **Mercury** in the morning is always a challenge before sunrise. It gets brighter during the first two weeks of June while sinking deeper into the twilight. On June 1 Mercury is magnitude 0; by June 11 it has grown to magnitude –0.8, but is 7° lower in the sky at sunrise.

On June 3, a waning crescent moon passes 1.6° south-southeast of Mercury in the gathering twilight. Your next view of Mercury might come in July's evening sky, three weeks after the planet's June 25 superior conjunction with the sun. □

Martin Ratcliffe directs the Henry Buhl, Jr. Planetarium in Pittsburgh, Pennsylvania. Rick Shaffer is a science writer living in Arizona.

Discover the Summer Sky

The weather's warm, the Milky Way's up, and the mosquitoes are hungry —it's the perfect time to explore the night sky with your small scope!

by Glenn F. Chaple, Jr.

You can't see too much with a small telescope. You really need a big light bucket like they have down at the Texas Star Party." I can't recall the number of times I've heard a comment like that at a star party. But it's simply not true. Small telescopes, those in the 2- to 6-inch range, provide fine views of hundreds of sky objects including many bright and moderately bright galaxies, clusters, and nebulae. And summertime is the best time to see many sky wonders, when the summer Milky Way arches high overhead. So dust off that small scope and get out under the stars!

One Giant Step

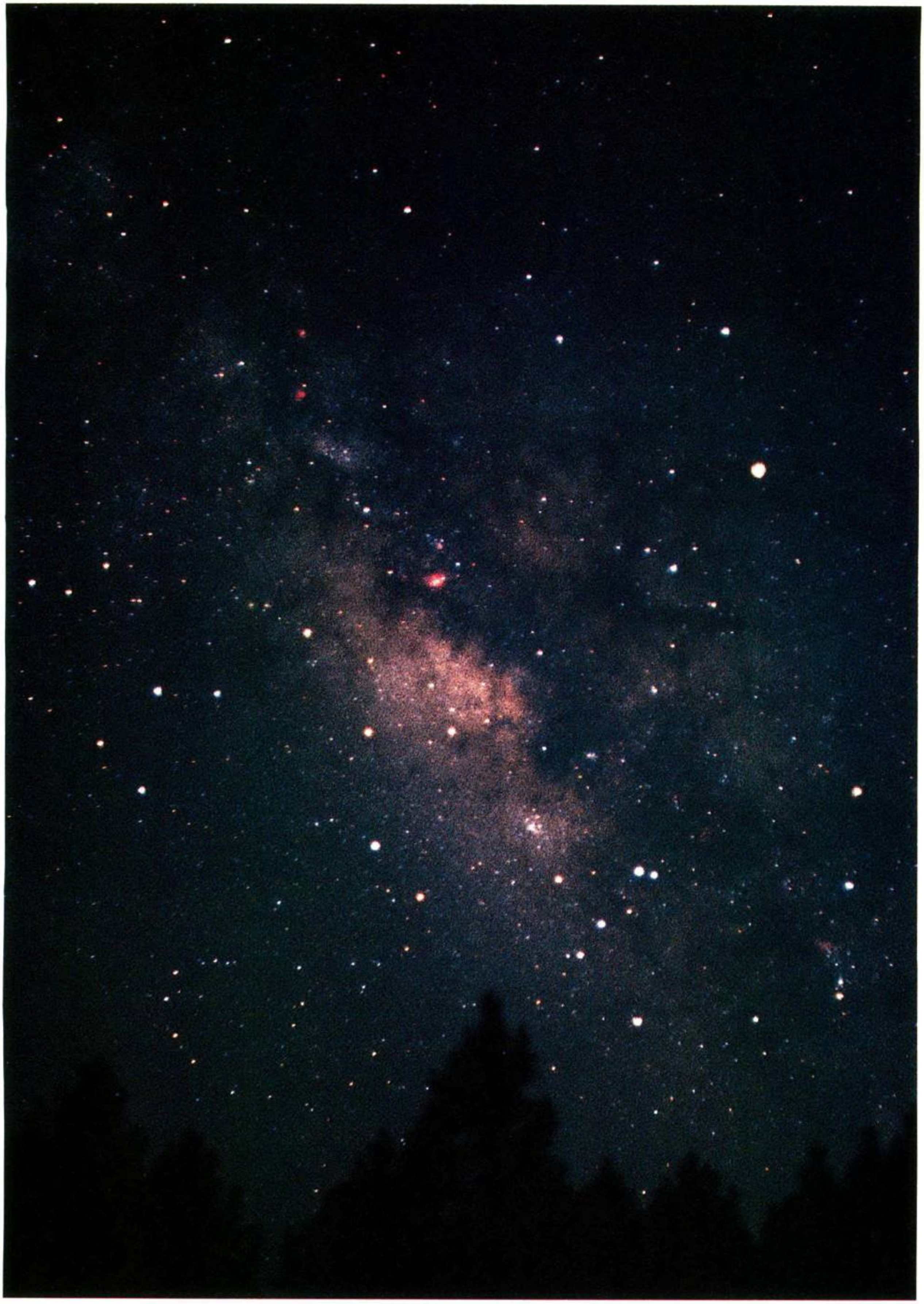
The moon is an astronomical neophyte's delight. It's big, it's bright, it's easy to find. And it's a great summer target, able to shine through the haze that often veils the night sky this time of year. Set your sights on the first quarter moon, which appears on the evenings of June 13, July 12, and August 11.

The "half moon," as poets are likely to call it, is a magnificent small-telescope sight. The best detail is seen near the terminator, where lengthy shadows betray rugged lunar topography. Look for the huge craters Albategnius and Hipparchus, located about one-third of the way down from the moon's south pole (remember, your telescope inverts the image, so south will appear as up in the eyepiece field). Each spans more than 80 miles, with Albategnius boasting the greatest depth — a whopping three miles.

Want to do some lunar mountain climbing? Our map shows the location of a semicircle of lunar ranges that begins with the Apennines and continues with the Caucasus and Alps. Some of these peaks rise three miles above the surrounding plains. Look carefully for the Alpine Valley — a 110-mile-long gash in the lunar Alps.

Use the moon to "power test" your telescope. Study the moon with all of your eyepieces — alone or in

The Summer Milky Way arches over the southern horizon. The most prominent constellations are Sagittarius, left, and Scorpius, right. Saturn floats majestically above and to the left of center, where the Lagoon Nebula glows red.



Jerry Schad

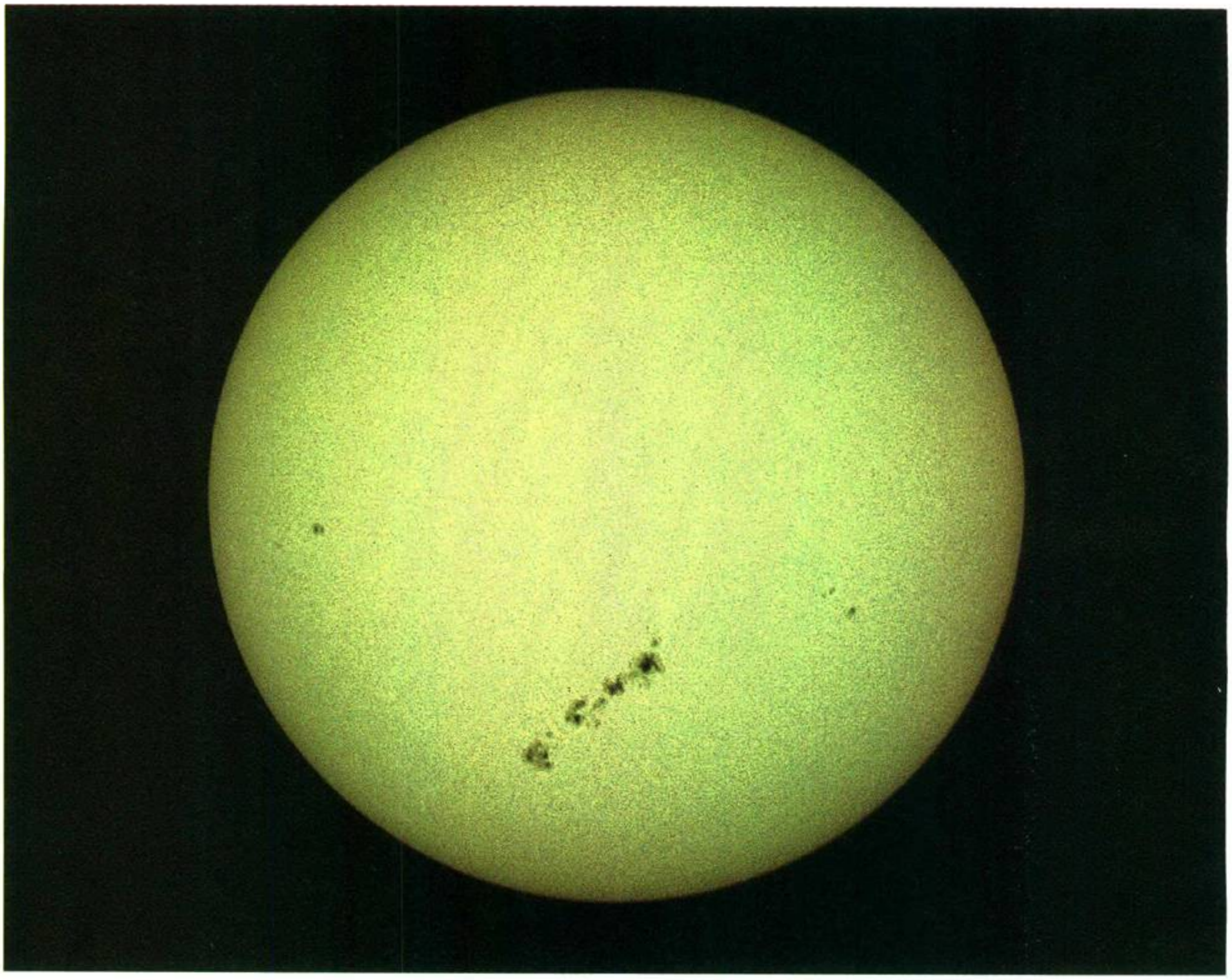
combination with a Barlow lens, if you have one. At what magnification does the moon begin to look blurry? Experts tell us that the maximum useful magnification for any telescope under ideal atmospheric conditions is about 50x per inch of its aperture, the diameter of its objective lens or mirror.

What is your telescope's magnifying power? That depends on the eyepiece you use. It is inscribed with letters (abbreviations for the eyepiece design), followed by a number (the focal length of the eyepiece, in millimeters). To find the magnifying power, simply divide the telescope focal length (inscribed somewhere on the tube or on the focuser) by the eyepiece focal length. Example: a 700mm telescope with a 20mm eyepiece yields 35x. Couple that with a 2x Barlow, and you have 70x.

A Journey to the Nearest Star

Summer is a time when millions of sun worshippers flock to the beaches to "catch a few rays." Astronomers catch rays, too — literally. They use their telescopes to capture sunlight and project a solar image on to a viewing screen.

Solar projection is an easy way to view the sun. It's a lot safer than viewing the sun directly through filters (and, come to think of it, a lot safer that sunbathing on the beach). Simply aim your telescope toward the sun while holding a sheet of white cardboard about one foot from the eyepiece. Focus until the sun's projected image is clear and sharp. Low power (about 30x) lets you view the entire solar disk, which may contain a few dark blotches. These are sunspots, and daily observations show their apparent drift across the sun as our star rotates. Watching the sun is an exciting pastime, and a great way to make astronomy a truly night and day hobby.



Rick Dilsizian

When viewed with a properly safe filter, sunspots offer a reason for backyard astronomers to set up their scopes during the day.

Summer Planets

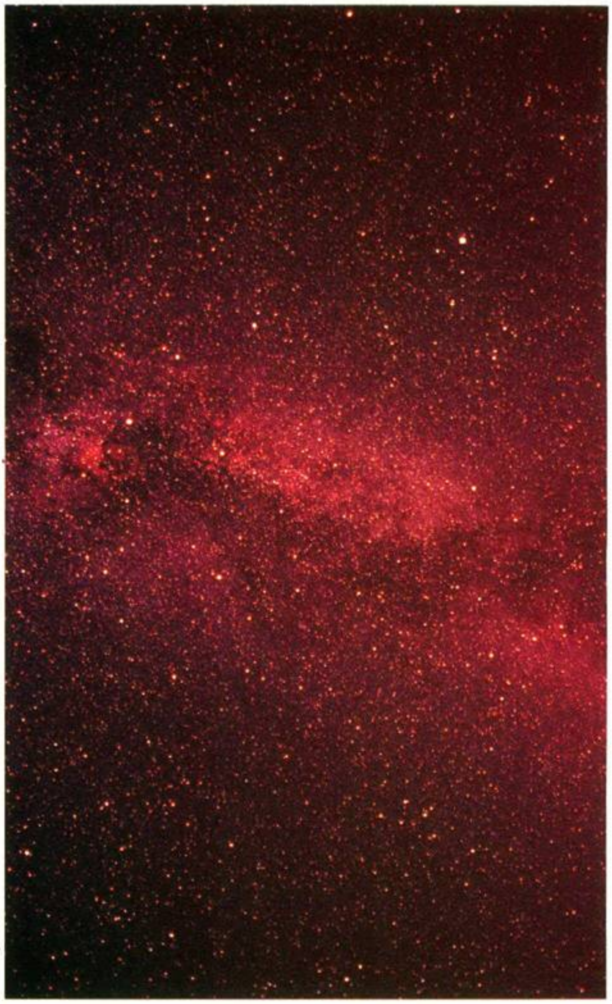
Can it really be that nearly two years have passed since the great comet-Jupiter crash? The scars from that cosmic collision (which, by the way, were seen nicely through small scopes) are long gone, but Jupiter remains a marvelous place to explore with small scopes. Just 30x shows the big planet's slightly flattened disk — pale yellow and traversed by several dark bands. Strung out to the sides are four starlike moons (fewer, if one or more is behind or in front of Jupiter). These are the Galilean satellites, discovered by that pioneer Italian astronomer nearly four centuries ago. Like Galileo, we can watch their orbital dance from one side of Jupiter to the other. Unlike

Galileo, whose telescopes were primitive by modern standards, we can "jack up the power" and study Jupiter more closely. Higher magnifications reveal structure in the cloud bands. You probably won't see the Red Spot, an Earth-sized storm in Jupiter's turbulent atmosphere which has faded from prominence in recent years.

Small telescopes can see a long way out into the solar system. Case in point: the planet Uranus, located 1.7 billion miles away. You'll find this remote world in Capricornus. Use low power to find a "star" in the indicated location for the date you're observing. If sky conditions are favorable, Uranus should appear as a tiny, ghostly blue disk when viewed with magnifications of 100x or more. To be sure you've spotted Uranus, make a repeat observation a few nights later. If your suspect has moved, you've joined the ranks of the relatively few humans who have ever viewed this distant world. And you did it without some gazillion-power observatory telescope.

A Quantum Leap to the Stars

A telescopic journey to the stars holds the promise of a Star Trek adventure, but be forewarned. The typical star is hardly the visual treat the moon, sun, and planets are. No matter what the magnification, all you'll see is a tiny point of light (if you see a large disk, something is wrong with your focus). The nighttime stars are reduced in apparent size by distances typically a million times greater than the gap separating us from our own star, the sun.

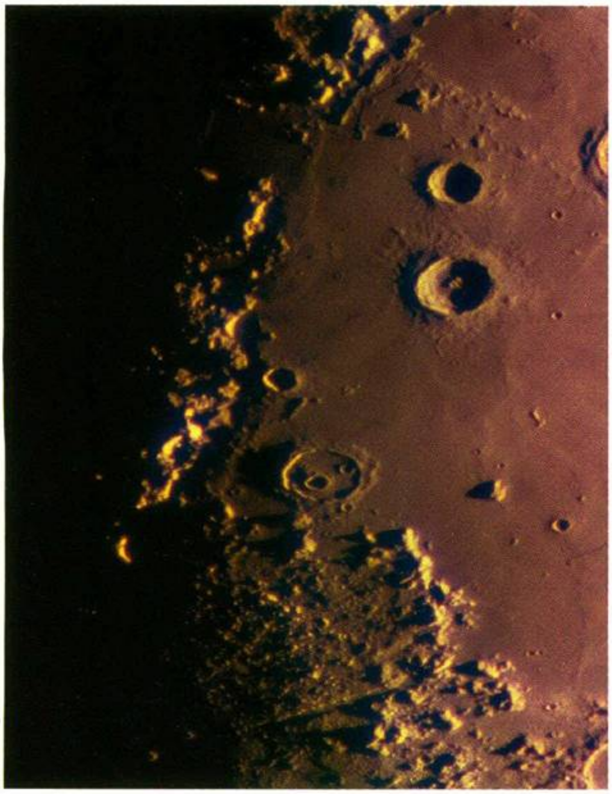


The Summer Triangle consists of bright stars Vega (near top), Altair (bottom right), and Deneb (left center).

Alan Dyer

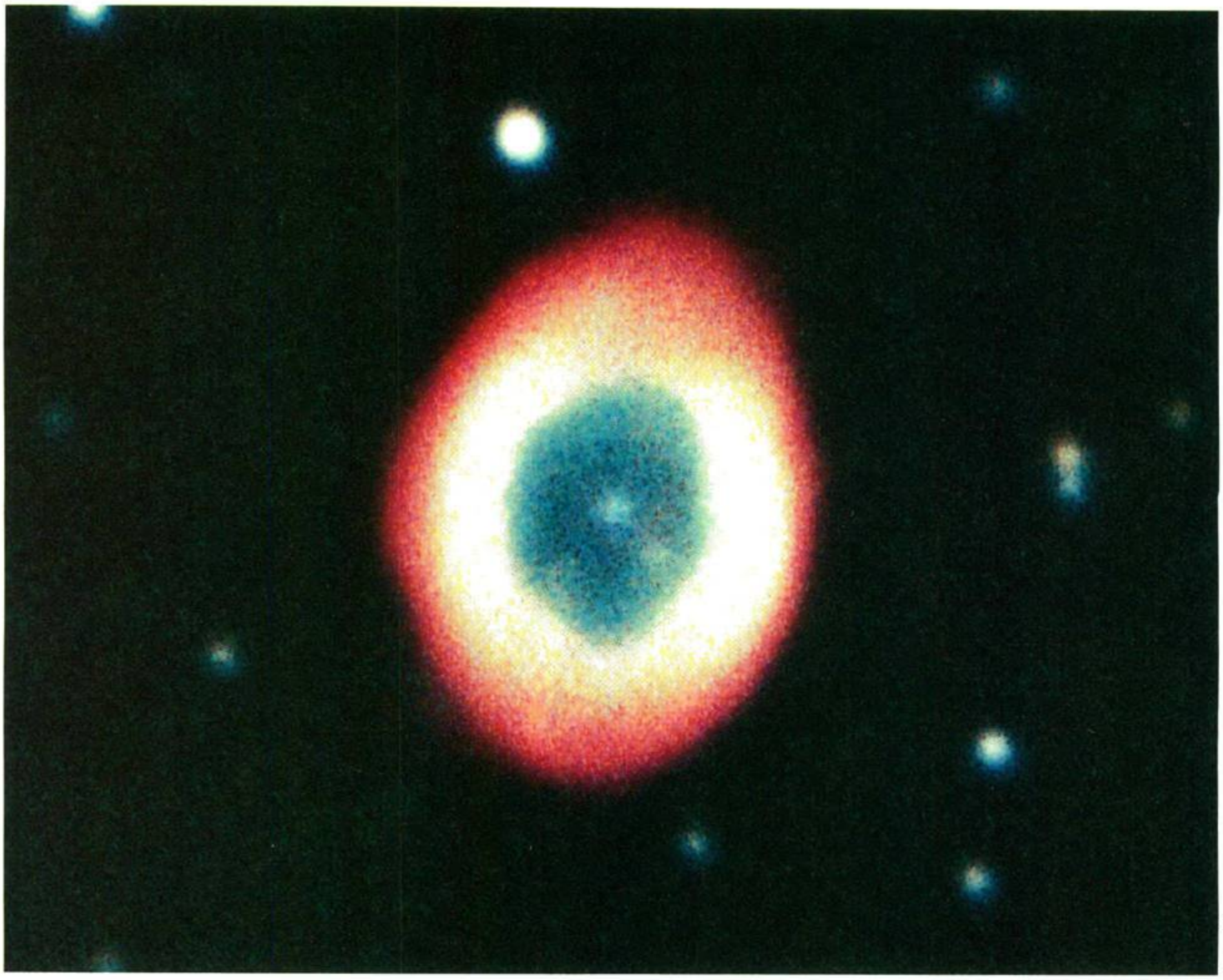
Still, if you point your telescope at one of the bright nighttime stars, magic happens. Check out Vega, brightest of the trio of stars that form the "Summer Triangle." What a dazzling telescopic sight — a blue-white diamond whose sparkling gleam has an almost hypnotic hold on the viewer. After admiring Vega for a few moments, tear yourself away and turn your telescope southward toward Scorpius and the 1st-magnitude star Antares. Glance at this fiery reddish-orange star and you'll understand why the Greeks called it the "rival of Mars." Antares, a giant with an estimated diameter more than 700 times our sun's, shines at us from a distance of 500 light years — 20 times Vega's distance.

Have you ever seen double, astronomically speaking? While a single star may not be a particularly inspiring telescopic sight, the addition of a second or third star close by creates a vision of delicate beauty. Antares is a double, but the companion star is too faint and near the primary to be seen with small scopes. Try Beta (β) Scorpii, to the right of Antares and above it by a few degrees. Here's a pretty stellar duo whose angular separation of about 14" is just one-third Jupiter's apparent diameter. Use medium magnification



The moon's Alpine Valley (the dark notch near bottom), a cleft in the floor of the surrounding mountain range, extends for 110 miles.

Jean Dragesco


Jason Ware

Visible in small scopes as a puff of cosmic smoke, the Ring Nebula (M57) in Lyra is one of the most distinctive planetary nebulae in the whole of the sky.

(50–60x, or a low-power eyepiece coupled with a Barlow lens). Look closely at the companion. It seems deep blue or blue-green when compared to the stark white main star. Since both have similar spectral types, this color difference may be an illusion resulting from their difference in brightness.

There's no question about the color of the two stars that make up Albireo, the second brightest star in Cygnus. Their astounding gold and blue colors (topaz and sapphire, if you're a lover of precious gems) rarely fail to draw gasps of amazement from first-time viewers. Veteran skygazers rank Albireo among the finest double stars in the heavens. Albireo is a wide pair (35") that looks best with powers around 30x. The colors appear richer in small scopes.

To the Outer Limits

How far are you traveling on your summer vacation? One hundred miles? One thousand? How about 120 quadrillion miles? That's the distance to the globular star cluster M13 in Hercules, and you can be there in seconds with a backyard telescope. Summer is the season for globular star clusters. Dozens of these giant stellar swarms hover around the hub of our Milky Way, now well-placed in the summer sky. The Hercules Cluster is one of the brightest and best-known globulars. It appears as a small, round patch of light in binoculars and finderscopes. Small telescopes enlarge this fuzzy ball — it's about one-third the moon's apparent diameter. You'll need a 6-inch scope or larger to view the cluster in its true glory. A globular cluster like M13, viewed with a large telescope, is an incredible sight — a heap of sparkling sugar on a backdrop of black velvet. But even through a small scope, it's mind-boggling to realize that the light from the fuzzy ball you're looking at began its journey toward Earth during the last Ice Age.

If M13 makes you long for the sight of "sugar on black velvet" through your small scope, try the rich open star cluster M11 in Scutum, called the Wild Duck Cluster. Open clusters are much younger than globulars, and are mostly confined to the plane of the Milky Way. Their stellar populations are much sparser; M11 contains at most several hundred stars concentrated in an area similar in size to M13.

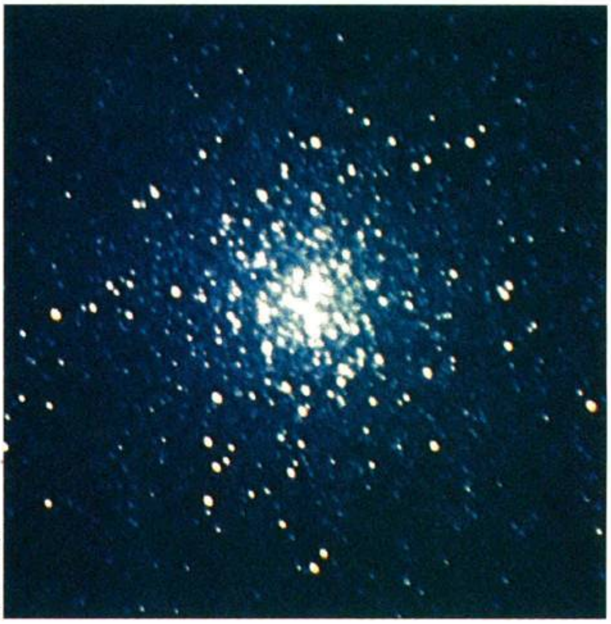
A survey of summer deep-sky objects for small scopes wouldn't be complete without mention of the planetary nebula M57, the famous Ring Nebula in Lyra. A rather small and faint target — it's only about twice Jupiter's apparent diameter and ten thousand times fainter — M57 is still well within reach of a small scope. As with any deep-sky object, M57 is best viewed on a clear, moonless night from an area free of bright outdoor lights. Use low power to scan the area midway between Beta and Gamma (γ) Lyrae. Once you've located a slightly oval, out-of-focus "star," center it in the field and switch to higher magnifications. Like its cousins, M57 was formed by a star that ejected a huge shell of gas in the last stages of its life. The gas bubble you're looking at spans half a light-year.

A Milky Way Cruise

Pursuing sky objects with a small backyard telescope is a great hobby. As you gain experience with your telescope, you'll find yourself falling into the ranks of the so-called "serious" amateur astronomers. And while "serious" work can be useful, we should never forget that a hobby is supposed to provide a good measure of relaxation.

Here's a summertime astronomy activity that's pure fun. On a clear night when the Milky Way is draped across the sky, place a low power eyepiece into your scope and point it as high on the Milky Way as you can. Peer into the eyepiece and continue gazing as you slowly move your scope along the Milky Way towards the horizon. Look at all the stars — bright and dim, single or in pairs, even triple and multiple. You may even stumble upon a cluster or two. Don't worry about identifying anything. Just enjoy the ride. Now and then you may need to make a mid-course correction (a clue you're running aground is the sudden sparseness of the telescope's field).

If you're a novice skygazer, I highly recommend that you take a Milky Way Cruise. If you're a serious veteran observer, I insist that you do so. ☐



David Healy

The most observed globular cluster in the northern sky, the Hercules Cluster (M13) holds a million stars in its gravitational grip.

Glenn Chaple is a teacher living in Townsend, Massachusetts. He is co-author of the Edmund Mag. 6 Star Atlas *and the author of many observing articles.*

Locked in the richness of the Scutum Star Cloud, the Wild Duck Cluster (M11, lower left) features a distinctive triangular shape.

Alan Dyer

Build a Backyard Observatory for Peanuts

A pre-fab kit from a local lumber yard becomes a gateway to the heavens. By Dave Kriege

Imagine ordering an astronomical observatory from your local lumber yard. The clerk hits a few keys on his or her computer and the monitor displays nearly everything you need, right down to the nails and a step-by-step construction guide. Sounds like a fairy tale, but that's essentially what I did for a 26- by 27-foot roll-off-roof observatory. At over 700 square feet, it's huge in comparison to other roll-offs.

Originally sold for constructing a two-car garage or an agricultural "pole building," the kit I selected was thoroughly engineered and tested. And because it's an "off-the-shelf" building, it was much cheaper to convert and raise than a custom-built structure. What's more, if I ever move away, the building can easily revert back to a two-car garage. (Astronomical observatories are generally worthless to prospective home buyers.)

A week after I paid the lumber yard clerk, a delivery truck rolled up and dumped all the materials at an observing site adjacent to my home. Two months later the observatory saw first light. My only major modification was to adapt the roof design so it would roll away easily. Now the 3,000-pound behemoth moves so easy that my observatory can be opened or closed with one hand in less than 20 seconds.

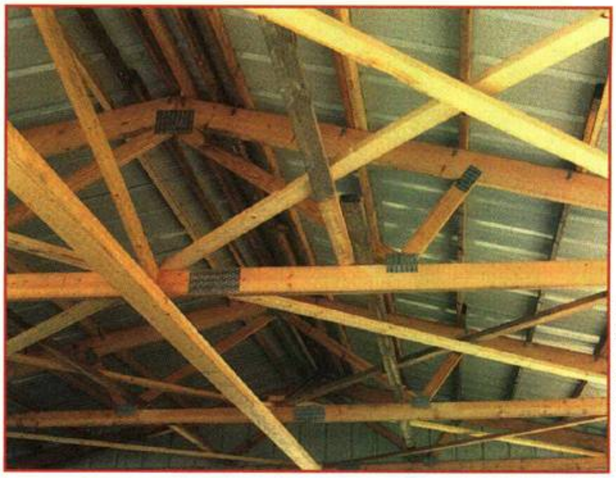
Observatory from a Can

By no means was the observing site completely undeveloped. I'd been observing on a 22- by 24-foot concrete slab at my site for three years before construction. This pad would double as most of the new building's floor. But first I had to determine the observatory's optimal size. This involved tying string between four 12-foot poles placed at each corner of the proposed observatory. At night I moved the poles around and adjusted the string's height until I settled on a wall height that was best for my 25-inch Dobsonian telescope. I wanted to observe down to a declination of –25° at the meridian and still leave a foot of wall all around to keep out stray light and wind. After I figured all of this out, I ordered the kit.

I simply selected a building that matched my requirements out of a catalog published by Menard's, a large home improvement chain store in the Midwest. Buildings started at 16- by 16-feet and increased in 2-foot increments up to hundreds of feet across. Wall height was entirely up to the customer. I deleted an overhead 16-foot garage door and windows from the original plan, but added posts and some 2x10s to hold the roll-off roof track. The cost, including delivery, was just under $2,500.

The building had three major components: posts, roof trusses, and galvanized white steel panels for the walls and roof. Some pre-fabricated buildings use aluminum wall and roof panels. I decided to stick with steel. While aluminum is one-third the weight of steel, it's not as strong and usually requires more trusses to support an extensive roof. The added weight and cost of extra trusses would cancel out any weight savings gained by using aluminum.

Observer Dave Kriege converted a two-car garage kit into a roll-top observatory for less than $12 per square foot. His 700 square-foot building comfortably houses a 25-inch f/5 telescope.



All photos by Dave Kriege

Criss-crossing 2x4s between trusses keep the roof square as it moves along a track. The 4x8 beam running diagonally from center is for a pulley and cable system Kriege eventually didn't need.

I also decided early on not to raise this building without professional help. With the materials on hand, I secured the services of two carpenters experienced in erecting these types of buildings. Their expertise and muscle produced a much better building than I could have ever done by myself. Believe me, manhandling 160-pound, 26-foot roof trusses is a task better left to professionals. Unless you're a skilled carpenter, I strongly suggest utilizing local talent to construct a large building.

Setting the Posts

My first construction step was to lay out the location of support posts. The east and west walls would have four 4x6-inch posts placed nine feet apart. Three more posts were planted toward the north on each side to hold a track that would accommodate the open roof. I added a six-foot-wide double door between the posts in the south wall to let me move large equipment in and out of the observatory. The north wall also has a small entrance door in the corner.

Take special care when you lay out the posts. A mistake now will haunt you later. The posts must be spaced so the building's corners are square. Ones that support the roof tracks should lie precisely in line with one another and be perfectly vertical. It took two trained carpenters four hours to lay out their location. What *kind* of post is also important: I settled on a "pressure treated" type of lumber that comes with a 20-year guarantee against rotting.

After I figured out the post layout, a commercial hole driller made five-foot-deep holes 18 inches in diameter. To prevent settling, 2-inch-thick, concrete pads spanning 14 inches were placed in the bottom of each hole under each post. The posts were then aligned and backfilled with dirt by hand and shovel. I left the posts longer than normal to make it easier to snap a horizontal chalk line before trimming them down to a final height. This trimming was an important step. A rolling roof would have been difficult to control if all of the posts on the east and west weren't trimmed to exactly the same height.

Pulling It Together

The next step was to make track beams for the east and west walls. Steel tracks positioned on top of these wooden beams would let me roll the roof on and off the building. The beams were made by nailing pairs of 2x10s together to a final length of 58 feet, a distance needed to get the roof far enough to the north to observe just below Polaris. I joined 16-foot lengths of 2x10 planks together with butt joints and toenailed them to the posts. Before permanently attaching them, I measured diagonally between the track beams to make sure they were parallel. The moving roof would bind in its track if they weren't. Any beam that was not in alignment was bullied into position.

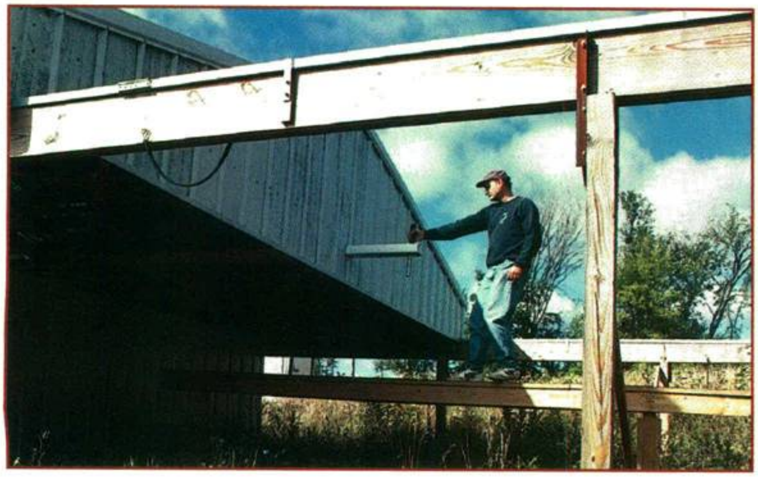
After the 2x10 track beam was nailed into place, next up was to get rid of any irregularities and warps. I did this by powerplaning down to a perfectly-straight line I snapped with chalk along the top quarter-inch of both plates. This extra step may seem overly cautious, but if the plate has any high or low spots, the steel track that the roof glides over will deform under the weight of the roof.

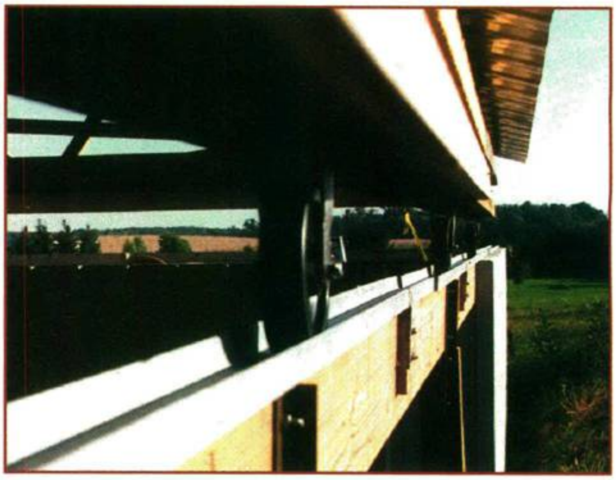
Finally, when everything was straight, level, parallel, and planed smooth, I firmly attached the track beams to each post with two-foot lengths of angle iron. These irons keep the beams from twisting over on top of the posts as the roof runs along its track during opening and closing.

With the track beams in place, I moved on to enlarging the concrete floor and putting up wall supports. Pressure-treated 2x6 boards around the building's perimeter acted as a form for the enlarged concrete floor. The tops of these boards were flush with the preexisting concrete floor level.

On top of these forms went horizontal 2x6 boards called "girts." The wall steel was eventually nailed to these girts. This steel siding came precut at no extra charge, which made assembly fast and easy. It extended from floor level to the top edge of each track beam, where it was nailed to 2x4 spacers. Except for the tracks and the beams, all of the installation procedures were explained in the building's construction booklet.

Kriege pulls the observatory's 3,000-pound roof along its 58-foot track. Asphalt shingles on the catwalk keep him from slipping.





Eight-inch diameter, 2-inch-wide phenolic wheels ride smoothly inside a 3½-inch-wide "C"-channel steel track.

Roll with the Roof Track

My observatory's roof would roll smoothly along a steel roof track made from structural "C"-channel steel measuring 4 inches wide at the bottom with 1½-inch-tall flanges. You can find such steel in 21-foot lengths at a welding shop. Each of my tracks used two 21-foot lengths and one 16-foot length that were secured together after they were placed on the 2x10 track beams I built earlier.

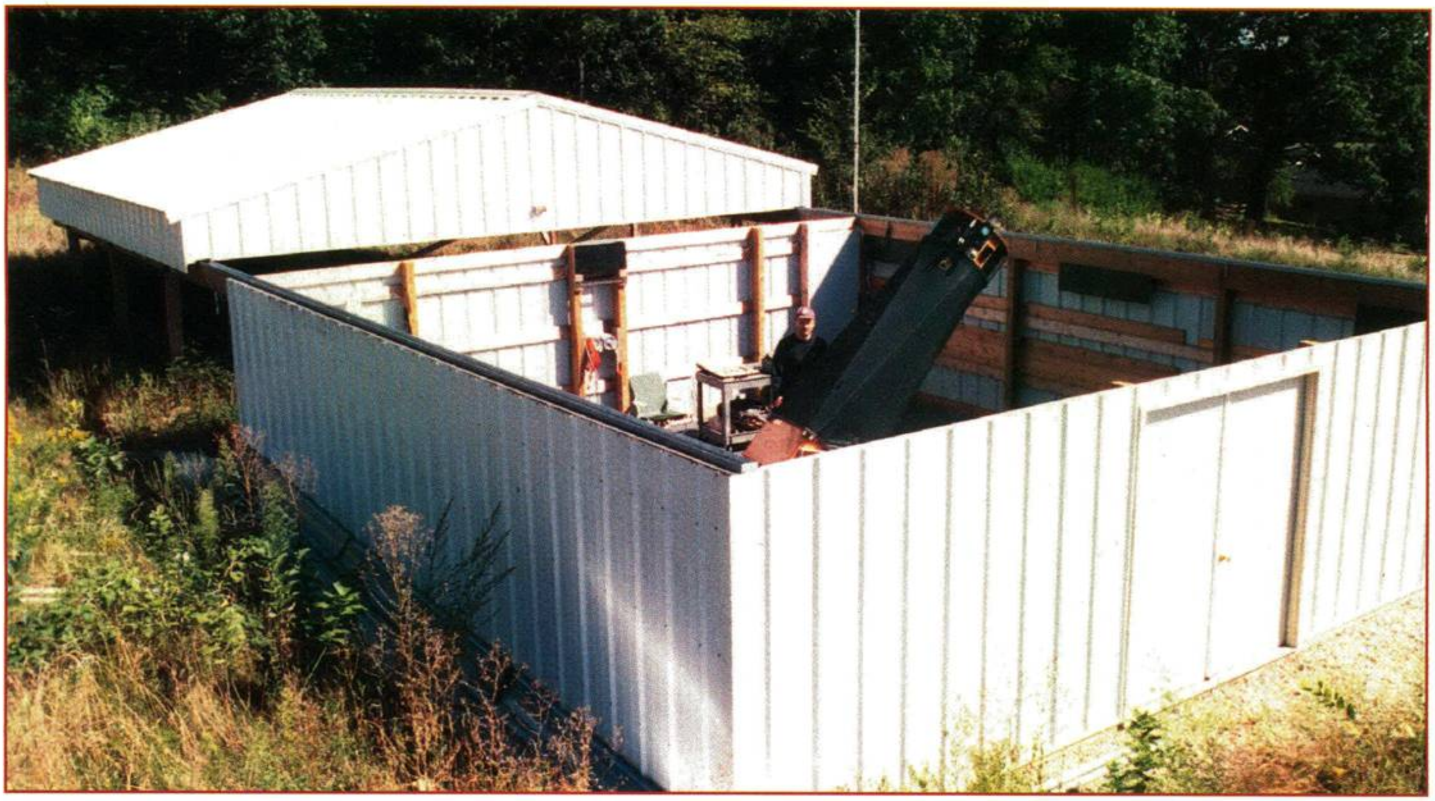
I hired a shop to weld a pair of steel straps to both sides of the track's flanges every few feet so I could secure the track to its beam. Bolt holes were drilled into each pair to straddle the beam and feed connecting bolts to the track beam underneath. A small steel "endstop" welded to the end of each track prevents the roof from being pushed too far. Quarter-inch drain holes for water were drilled every few feet. Finally the track sections were sent out to be galvanized. Total cost for the finished tracks was $1,000.

When the finished segments were delivered, I set them on top of the 2x10 track beam and bolted them into place. Connecting straps held each track section together. After a few months, two of the track sections shifted about half an inch. If I were to do it over again, I'd have the welding shop attach some heavier connecting straps to each joint.

My native Wisconsin sees temperature extremes of –30° F in the winter and 100° F in the summer. Not surprisingly, the observatory expands and contracts. A change of one-tenth of one percent over a 26-foot-long roof truss will mean a dimensional change of ⅓ of an inch. The extra-wide track I selected allows for these seasonal changes. Its 3½-inch width provides ample clearance between the wheels and the sides of the track.

A Roof on Wheels

Selecting the right wheels also helps me cope with a shifting building. I settled on 8-inch-diameter, solid phenolic wheels that are two inches wide. Their 900-pound capacity was more than adequate to support a 3,000-pound roof. They came mounted in a solid bracket with four mounting holes. They



A 7-foot wall blocks wind but lets Kriege observe to within about 20° of the horizon. The double doors are for moving equipment.

also feature what's called a "zerk fitting" for easy oiling. I bought eight of these wheels to mount under the ends of the four roof trusses.

The roof takes shape around these four trusses, one at each end with two in the middle. The trusses sit nine feet apart and are attached to a 4- by 10-inch wheel plate that runs perpendicular to each truss along the length of the roof. As with the track beams, the wheel plates were made by nailing two 2x10s together. A wheel plate gets four wheels attached to it, evenly-spaced and bolted so they are directly under a truss. It's crucial that the wheels line up perfectly along the length of the wheel plate. To ensure this, my carpenters snapped a chalk line on the underside of each plate to align the wheel mounting brackets.

To keep the roof square while it moves, I instructed the carpenters to brace the undersides of all the roof trusses with diagonally-placed 2x4s. This completely prevents the roof from warping.

With the roof trusses set, next came the purlins, 2x4s set on end every two feet along the trusses. Two-by-four wind braces were attached diagonally from the peak of each end truss to the bottom cord of an adjacent truss. Then the precut roof steel was nailed to the purlins. Finally, gables (exposed trusses) at the north and south end were covered with steel siding. A 3½-inch overhang between the roof and its track provides ample air flow. Even in direct sunlight, the building is never more than 5° warmer than the outside air.

Finishing Touches

With the building completed, my old concrete pad was expanded to create a solid 26- by 27-foot observing floor. To prevent track posts that support the retracted roof from drifting east or west, I braced them to some short posts planted between each pair of track posts. Should the track posts warp over the years, it's a simple matter to knock off the braces, pull the track posts back to vertical, and then renail them to the short posts.

Those same short posts support a catwalk that extends from the middle of the north wall. A short pipe that sticks down from the central roof beam allows me to grab the roof at waist level. Asphalt shingles on the catwalk keep my feet from slipping on nights when there's heavy dew.

When the roof is rolled shut, I secure it with heavy-duty nylon "ratchet tie-down" straps in each corner to keep the wind from blowing it away. These straps are used by truckers to secure loads to flat bed trucks. One end attaches to the bottom of a roof truss (not the plate), while the other end runs through a big eyebolt mounted through a corner post.

All told, the observatory, which I call "House of Obsession" after my telescope business, ran about $12 per square foot to build. The final tally includes everything supplied by the lumber yard, site prep, the steel tracks and wheels, the concrete floor, and all labor. Considering my observatory's size, the whole project cost peanuts. A more modest building for a smaller telescope would run significantly less. For example, a typical 18- or 20-inch Dobsonian could easily fit inside a $4,000 building. With that level of economy, it's hard to resist an off-the-shelf, roll-top observatory. □

Dave Kriege (obsessiontscp@globaldialog.com) is a dentist and owner of Obsession Telescopes in Lake Mills, Wisconsin.

Charting the Moon by Eye

Larry Landolfi

Stalking Luna's surface features with the naked eye requires timing, precision, and skill.

by Edmund A. Fortier

Imagine a crisp, clear morning just before dawn. The waning gibbous moon, scarcely past full, still rides high in the western sky. Bright enough to cast shadows through most of the night, the moon now is a pale disk, its surface textured with soft, delicate detail. You think you recognize some of the more prominent features and wonder how many others might be visible to a sharp-eyed observer.

The answer, surprisingly, is quite a few. The moon's diameter (2,160 miles) and average distance from Earth (239,004 miles) combine to yield an image that spans half a degree of sky. Although this is large compared to the angular width of other solar system objects, it's smaller than many people realize — about the size of an aspirin held at arm's length. Yet in terms of discernible surface features, the moon offers about as much detail to the unaided eye as does the planet Mars at opposition when viewed through a medium-size telescope.

Success in identifying lunar surface features, particularly subtle ones, doesn't depend entirely on good observing conditions and visual acuity. You must also know what to look for and where to find it. That's an advantage early moon watchers didn't have, and it affected the accuracy of their observations. The only known moon map that predates the telescope was made by the English scientist William Gilbert. Although Gilbert was a careful observer, his placement of the lunar maria only roughly approximates their actual location. Early telescopic drawings of the moon tend to be equally imprecise — or worse. None of the features recorded by Galileo, for example, correspond to any known lunar formations.

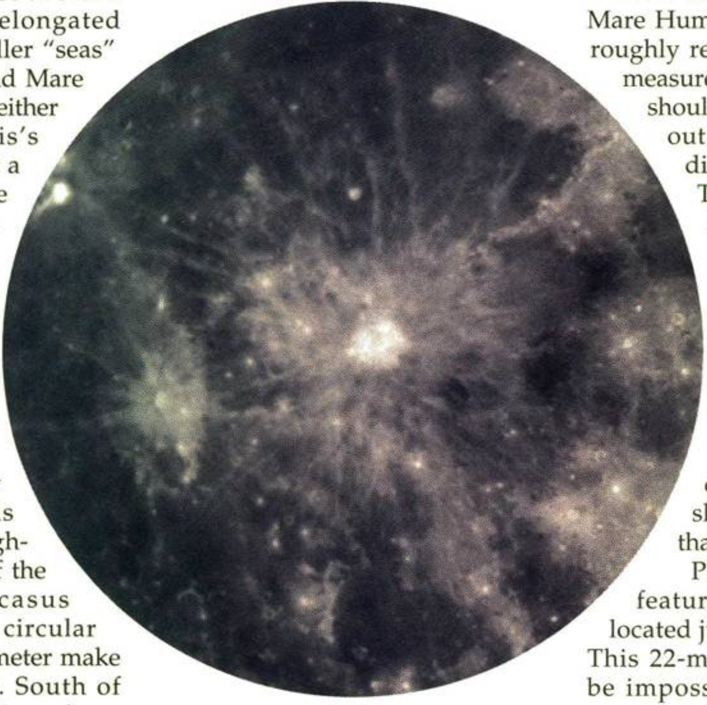
Therefore, in order to detect faint surface features, you must first be thoroughly familiar with the moon and its topography. The most brilliant region of the lunar disk is the southern highlands, a crater-strewn area that is virtually featureless to the unaided eye. In contrast, the northern and western hemispheres are dominated by a number of well-defined dusky markings. These dark areas are the maria, vast basaltic plains that formed about 3.8 billion years ago when lava from the moon's interior oozed to the surface and flooded gigantic impact basins. The most elusive details are generally found along the boundaries of these two regions, where tones and shadings are enhanced by contrast.

The maria are the moon's largest surface features and consequently the easiest to see. Close to the eastern limb, at about two o'clock, is the small, detached spot that is Mare Crisium. Just to its west lies Mare Tranquillitatis and above that, Mare Serenitatis. Together, these two lava plains appear as an elongated dusky patch. Two smaller "seas" — Mare Fecunditatis and Mare Nectaris — extend from either side of Tranquillitatis's southern rim and give it a forked appearance. The Fecunditatis branch is the more prominent of the two, but you should be able to detect the Nectaris branch as well.

West of Serenitatis is Mare Imbrium, the largest impact structure on the moon. Clearly defined, this feature is separated from its neighbor by the thin curve of the Apennine and Caucasus Mountains. Its nearly circular shape and 900-mile diameter make it visually distinctive. South of Imbrium, and extending along much of the western side of the moon, is the vast expanse of Oceanus Procellarum. At its most southern extent you'll find two small dusky lobes, Mare Humorum and Mare Nubium. Skirting the northern edge on the moon is the narrow strip of Mare Frigoris. Despite its faintness, this feature is visible even to casual moon watchers as an indistinct line just above the Imbrium basin.

Now that you're familiar with the moon's overall appearance, it's time to put your observing skills to the test. The accompanying map plots 12 naked-eye objects in increasing order of difficulty. The list, known as Pickering's Dozen, was devised by William H. Pickering. He was brother and assistant to E. C. Pickering, longtime director of Harvard College Observatory, and used the list to test the eye's ability in discerning faint detail. While you might not spot them all, remember that many of these features can only be seen during evening and morning twilight, when glare from the moon is least intrusive.

First on Pickering's list and the easiest of the 12 to see is the crater Copernicus. Measuring 56 miles in diameter, it's located about midway between Mare Imbrium and Mare Nubium. Besides being the single finest example of a lunar crater, Copernicus also possesses a magnificent system of rays, surpassed only by the Tycho system. Look for it at full moon, when the rays are most prominent and the entire area appears as a bright spot against the gray expanse of eastern Oceanus Procellarum.



Perhaps the finest example of a lunar crater, Copernicus has a ray system surpassed only by Tycho's. Lee C. Coombs

Gérard Therin

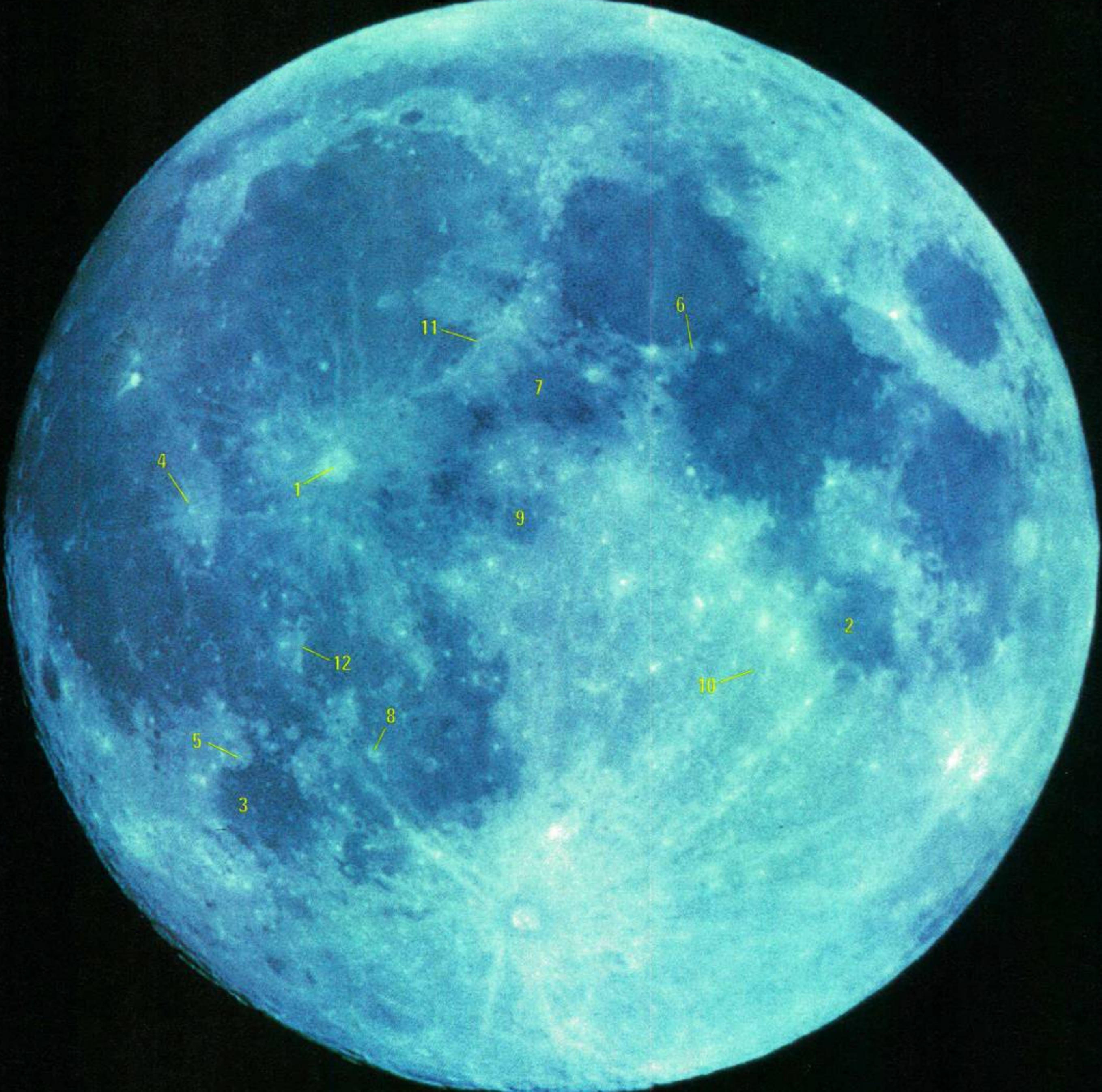
The Gassendi plain stands out on the northern edge of Mare Humorum.

Next come Mare Nectaris and Mare Humorum. Mare Nectaris is roughly rectangular in shape and measures 180 miles across. You should be able to see it without too much trouble as a distinct spot below Mare Tranquillitatis. Mare Humorum is circular and somewhat larger (about 286 miles across), but it also lies close to the moon's western limb and due to foreshortening, appears oval . Its well-defined borders and dark floor make it only slightly less conspicuous than Mare Nectaris.

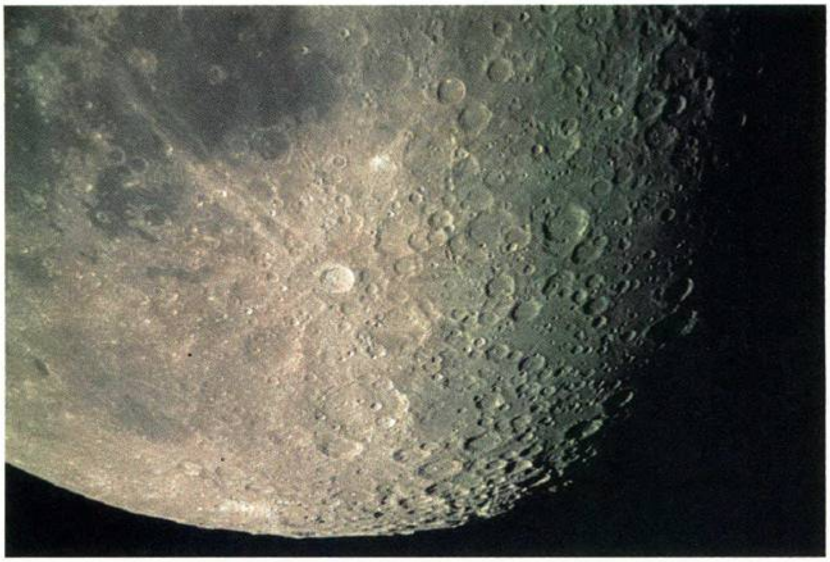
Pickering's fourth test feature is the crater Kepler, located just west of Copernicus. This 22-mile-wide object would be impossible to detect were it not for the brilliance of its ray system at full moon. Expect to see a smaller, dimmer version of Copernicus. Not far to the south,

Can you pick off Pickering's list?

1 Bright surroundings of Copernicus
2 Mare Nectaris
3 Mare Humorum
4 Bright surroundings of Kepler
5 Region of Gassendi
6 Notch in the Mare Tranquillitatis-Plinius region
7 Mare Vaporum
8 Light area around crater Lubiniezky
9 Sinus Medii
10 Shaded area near the walled plain Sacrobosco
11 Dark spot at the foot of the Apennines
12 Riphaeus Mountains



Ken Jents



Ken Jents

Tycho, with its stunning ray system, stretches northward to the walled plain Sacrobosco. Can you find Pickering's challenge just above one of the rays?

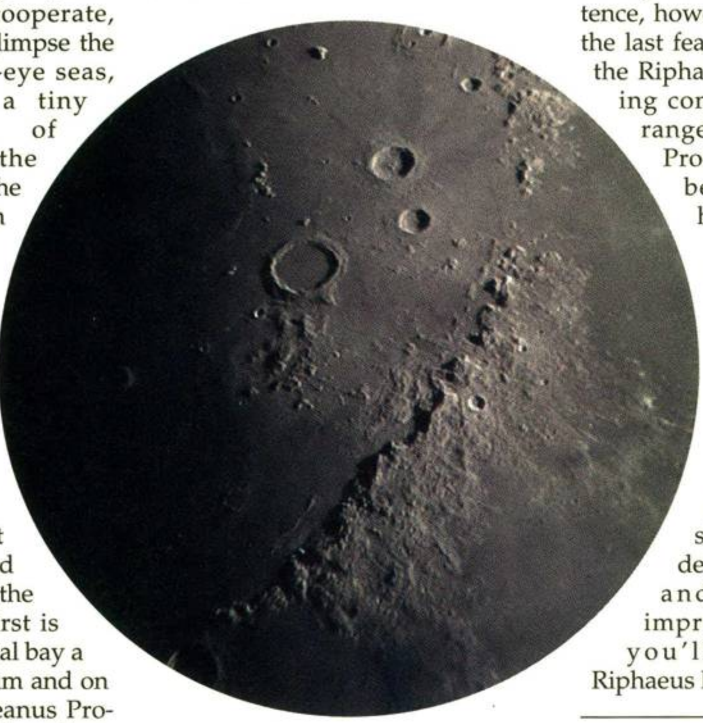
at the northern edge of Mare Humorum, lies the region of Gassendi. A walled plain some 70 miles in diameter, Gassendi is part of a larger area of cratered terrain that divides Mare Humorum from Oceanus Procellarum. Can you detect a brightening along the mare's northern shore?

Turn next to the Mare Tranquillitatis-Mare Serenitatis region. To the naked eye there is no clear division between these two seas, which seem to merge into a single oblong patch of gray. Look for a tiny notch about midway along the western edge. This indentation marks the southern rim of Serenitatis and is actually a blend of two features: the headland range of Promontories Acherusia and the 30-mile-wide crater Plinius. The peaks of the former rise almost 5,000 feet above Mare Serenitatis; Plinius, just to the east, lies on the northern shore of Tranquillitatis.

Once you've located the Plinius region, you're half-way home, but don't get too confident. As you might expect, the last six objects on Pickering's list are considerably more difficult — smaller, fainter, and less defined.

If your eyesight is good, and observing conditions cooperate, you should be able to glimpse the smallest of the naked-eye seas, Mare Vaporum, as a tiny smudge southeast of Imbrium. Try to spot the light area surrounding the crater Lubiniezky, on the northwestern shore of Mare Nubium. Lubiniezky is located in a region bright with streaks and rays — including one of Tycho's, which passes just to its southwest — this is best seen during a full moon.

You'll need excellent vision and possibly a good deal of practice to snare the next two objects. The first is Sinus Medii, a small marial bay a little below Mare Vaporum and on the eastern shore of Oceanus Procellarum. It will appear, if at all, as a very small, dark spot. If it seems too conspicuous, your eyes may be misleading you; it's easy to perceive the Mare Vaporum-Sinus Medii area as a single shadowy marking. Next on Pickering's scale is the faintly shaded area near the walled plain Sacrobosco. Situated in the lunar highlands southwest of Mare Nectaris, this feature lies just above one of Tycho's bright rays. You're a keen-eyed observer if you can detect this small variation in surface tone.



The spectacular Apennine Mountains, terminated by the crater Eratosthenes, stand southeast of Mare Imbrium. Mark Chamberlain

Pickering's eleventh test feature may be beyond your reach. Still, whenever observing conditions are ideal, make a point of scanning the Imbrium side of the Apennines for a tiny dip in brightness. That dip is a small portion of the Imbrium floor bound on either side by brighter surface material. If you don't find it at first, repeated attempts may bring success. Persistence, however, may not work for the last feature on Pickering's list, the Riphaeus Mountains. Pickering conceded that this small range in southern Oceanus Procellarum was probably below the threshold of human vision.

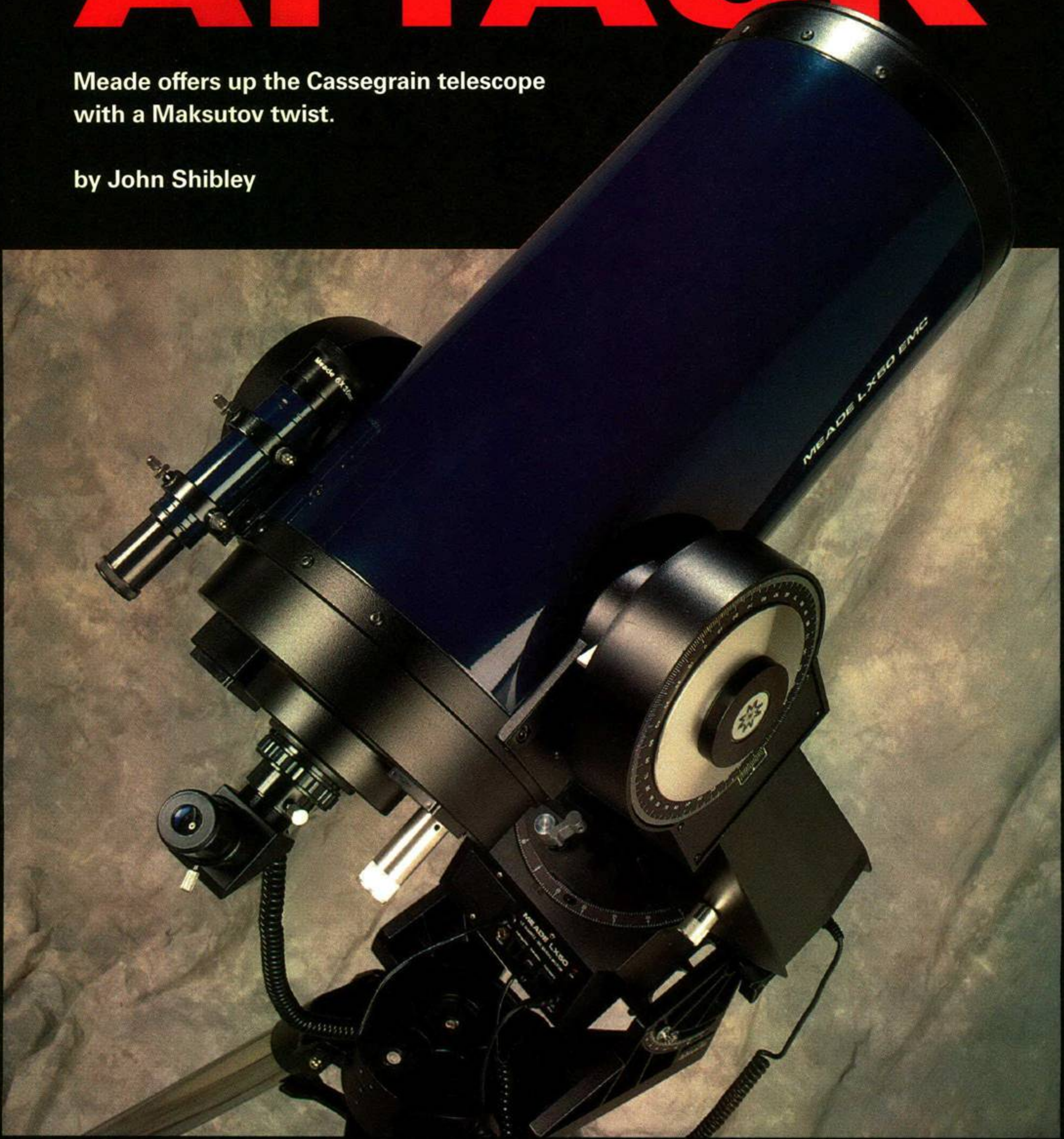
The moon is a challenging naked-eye object. To be sure, the larger maria are easy to spot, but searching out Luna's more elusive surface features can push your observing skills to the limit. With practice and persistence, your ability to detect these faint shadings and subtle tones will improve. Perhaps one day you'll even glimpse the Riphaeus Mountains. □

Edmund Fortier's last article in ASTRONOMY *was* The Mars That Never Was *(December 1995).*

BIG MAK ATTACK

Meade offers up the Cassegrain telescope with a Maksutov twist.

by John Shibley


MEADE LX50 EMC
MEADE LX50

Take a look at the automobile market and you'll see cars designed for certain types of driving — a touring sedan offered by Lexus won't work off-road as well as a Jeep. That same philosophy's found a home in the telescope business. Large-aperture reflectors are tailored for cruising the deep sky, while long-focus refractors are optimized for lunar and planetary work. In this vein, Meade offers a 7-inch Maksutov-Cassegrain intended to provide higher-magnification views in a compact package. ASTRONOMY tested out this particular scope. Here's what we thought of it.

Long Focus in a Small Package

A 7-inch Mak-Cass is ideal for CCD camera users. Why? For one thing, the scope has a substantially higher focal ratio than other scopes on the market, except for long-focus refractors which are not nearly as portable. The 7-inch Mak-Cass's slow f/15 photographic speed poses no problem to a photon-hungry CCD, which has a sensitivity to light several orders of magnitude greater than conventional film. The Mak-Cass's f/15 ratio also yields a narrower field of view than f/10 Schmidt-Cassegrains. This is ideal for smaller targets like planets. At f/15, a planet's image scale covers a greater area of the CCD camera's chip.

Visual observers appreciate longer f-ratios as well. Eyepieces work at a higher magnification than they normally do in a smaller f-ratio telescope. Higher magnifications are best for gleaning small detail on the moon and planets. They also yield a darker sky for catching fine detail in a deep-sky object.

Meade does offer a telecompressor for observers who prefer wider visual fields and for photographers who crave faster photographic speed. The accessory threads into the back of the scope and knocks the focal ratio down to f/9.5. This gets it into a range more familiar to owners of Schmidt-Cassegrain telescopes.

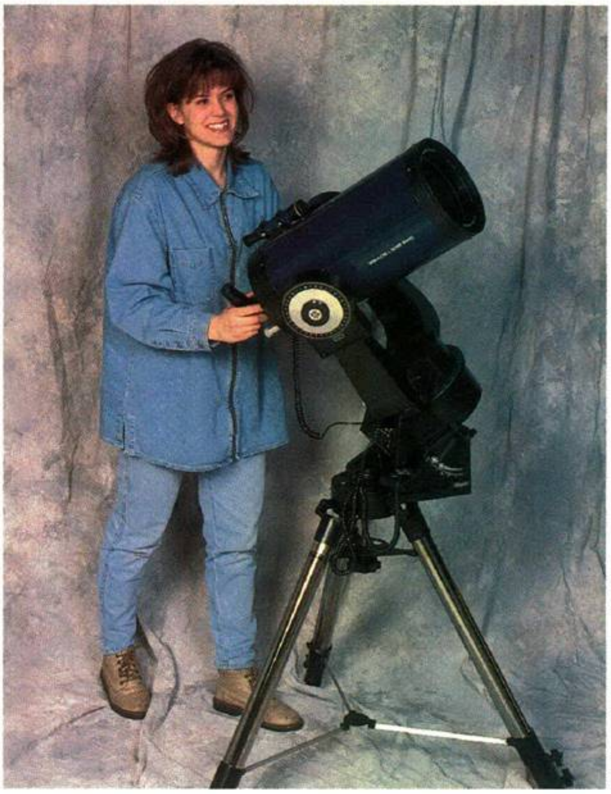
But what really makes a Maksutov-Cassegrain different from its nearest cousin, the ubiquitous Schmidt-Cassegrain telescope?

The Mak-Cass uses a primary mirror with a concave surface determined by the radius of a circle. Such "spheroid" mirrors offer distinct advantages over "paraboloids," whose concave surfaces are described by a parabola. For one, spherical optics are easier to make and test.

But spherical optics have a greater chance of suffering from optical aberrations. To get around this, the Maksutov's meniscus-shaped corrector precisely bends and modifies light that passes through it to eliminate errors introduced elsewhere in the optical system by spherical optics.

While a Schmidt corrector does control aberrations, it must rely upon the help of a non-spherical secondary mirror to get the job done completely. This adds a layer of complexity where quality problems can creep in. Staying on top of these factors would drive up the expense of producing a scope. Hence, the simple appeal of a Maksutov-Cassegrain is its exceptional performance at a modest price.

One more tiny difference also lies in the secondary mirror. Schmidt-Cassegrain secondaries periodically have to be tweaked for optimal optical alignment. On Maksutovs, this mirror takes the form of a maintenance-free, aluminized spot on the corrector plate.



All photos by ASTRONOMY: Jim Forbes

Meade's LX-50 7-inch Maksutov-Cassegrain package includes a fork-mounted telescope tube assembly and a latitude wedge. One crucial component, the field tripod, will cost you a little extra.

Survey Your Money's Worth

Meade offers its 7-inch f/15 Mak-Cass in three variations: as an optical tube assembly only, as part of an LX200 computerized mount system, or in an LX50 equatorial telescope package. ASTRONOMY chose to review the LX50 version because it offered the least expensive way to get a completely functional 7-inch Maksutov-Cassegrain system.

The LX200 version offers more bells and whistles, but at a higher price. It works as a computerized alt-azimuth scope that can track the sky without need for polar alignment. You set up and calibrate the LX200's electronic drive on two or three stars out of a library of 351 calibration stars in the drive computer's memory. That memory also contains the location of 64,000 objects to which the scope can slew. The LX200 even works equatorially with an optional wedge, an alignment most preferred for long-exposure photography.

The LX50, on the other hand, is economical simplicity. An optional $295 field tripod, a necessity if you want to observe, makes for a completely functional telescope. An included wedge lets you adjust the scope for any viewing location. A plug-in hand paddle slews the scope in two directions at four different rates. Those who want a little more sophistication for their observing can buy the Magellan II system ($495) which adds advanced digital setting circles and a 12,218-object database.

Out of the Gate

The LX50 package and its optional field tripod are shipped in separate boxes. The fully-assembled scope comes in its own container, surrounded by die-cut foam. The wedge arrives in pieces with assembly hardware, as does the tripod. A fourth box contains accessories and a finder scope.

The scope's shipping container doubles as a carrying case. I would have preferred that Meade supply a bona fide carrying case, as they've done for other scopes in their line. Durability might be a problem after several dew-soaked nights in the field. Consider searching a discount department store for a trunk that might work well as a case.

After unpacking the scope and setting its shipping/carrying case aside, I turned my attention to the field tripod, which assembled in about 15 minutes. An oversized knob locks the tripod open and holds the equatorial wedge in place. The wedge itself assembles with four knobs. Two knobs serve as a pivot point while the other two lock the wedge in place at a desired angle. Three more knobs let you attach the scope to its wedge. Don't forget to use the washers provided with the knobs. Failure to do so could damage the knobs as you tighten them down.

An equatorial wedge essentially angles the scope's right ascension axis so it will move parallel to the sky. To do this, the axis must point to the celestial pole, which in the Northern Hemisphere is roughly marked by Ursa Major's Polaris. You can adjust the wedge angle while looking through the scope at Polaris. This kind of rough polar alignment is often close enough to afford adequate tracking for general observing. Astrophotographers who need precise alignment usually pinpoint the pole's actual location some 1° from Polaris.

STANDARD SPECIFICATIONS

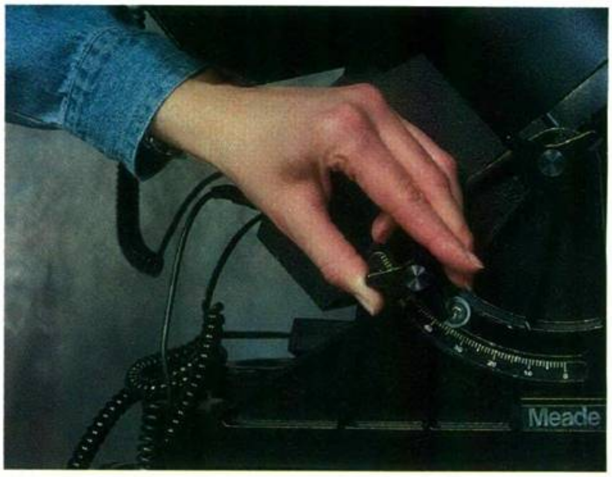
Aperture: 7.1 inches (178 mm)
Focal ratio: f/15
Focal length: 2,670 mm
Focuser size: 1.25 inches
Included 1.25-inch eyepiece: 24 mm (Modified Achromatic, 111x)
35mm photographic field, prime focus: 0.5° by 0.8°
Weight of tube assembly: 50 lbs.
Weight of tube, wedge and optional tripod: 76 lbs.
Warranty: one year, materials and workmanship
Suggested list price: $3,295
Typical retail price: $1,799

(Includes wedge, hand controller, power cords, 6x30 finder, 1¼-inch star diagonal and 24mm Modifed Achromatic eyepiece.)

OPTIONAL ACCESSORIES

Field tripod: $295
Telecompressor (reduces focal ratio to f/9.5): $208
(Suggested list prices; actual prices vary with dealer)

Meade Instruments Corporation
16542 Millikan Ave., Irvine, CA 92714
(714) 756-2291



The wedge guarantees the polar axis will track with the sky. Numbers on the wedge's scale correspond to an observer's latitude on Earth. An oversized knob locks the wedge setting into place.

Once the wedge is set, you should not have to readjust anything unless you move to a different latitude. You can also set the wedge angle by using its imprinted scale, but this doesn't afford the same level of accuracy as Polaris-sighting.

A Scope and Its Features

Three hand knobs secure the scope to its wedge through holes in the telescope's base. This base also holds a battery pack, a power switch, and six outlets which take standard and optional plug-in accessories. A standard jack outlet powers the declination motor, while another will accommodate any accessory with a compatible power cord. Three phone-type jacks are for optional digital setting circle encoders, an optional autoguider, and an included hand paddle that slews the scope. One more outlet accepts power from your car's cigarette lighter through a 25-foot cord.

The 7-inch LX50 Maksutov telescope I evaluated runs on six AA alkaline batteries that slip into a compartment built into the telescope's base. This power pack runs the LX50's motorized right ascension and declination axes as well as a ventilation fan built into the optical tube assembly.

I took the scope out on two occasions when the thermometer dipped below zero and found no problem getting power to the motors. The same set of batteries powered the scope in my house for an additional 10 hours non-stop before degrading to the point where an indicator LED built into the telescope's base did not light.

But all did not go well with the power at first.

After putting the scope together and loading batteries into its power pack, I flipped on the console power switch. The declination motor immediately started slewing uncontrollably. After reloading the batteries and rechecking power cord connections, I turned the unit on again. This time nothing happened.

Now I figured I'd blown a fuse. Removing the console's cover plate revealed that the 1-amp fuse was good. Closer inspection, however, came up with the source of my woes: a pinched wire between the battery pack and control board. Its insulation had been punctured and the wire almost severed when it was squeezed between a mounting plate and a pin. A quick electrical repair and careful repacking cleared up the problem. Everything worked fine after that.

You slew the LX50's two electric drive motors with a hand paddle that plugs directly into the telescope base. Pushing E or W makes the scope's right ascension drive slow down to move the field of view east or speed up to move the view west. Pressing N or S activates the declination motor, housed in the fork's right arm. This makes the scope nod up in a northerly direction, or down to move south. A speed button toggles through an array of slew rates: 2x moves the scope up (north), down (south), left (east), or right (west) at half a degree per minute; 8x slews at 2° per minute; 16x, 4° per minute; and 32x, 8° per minute.

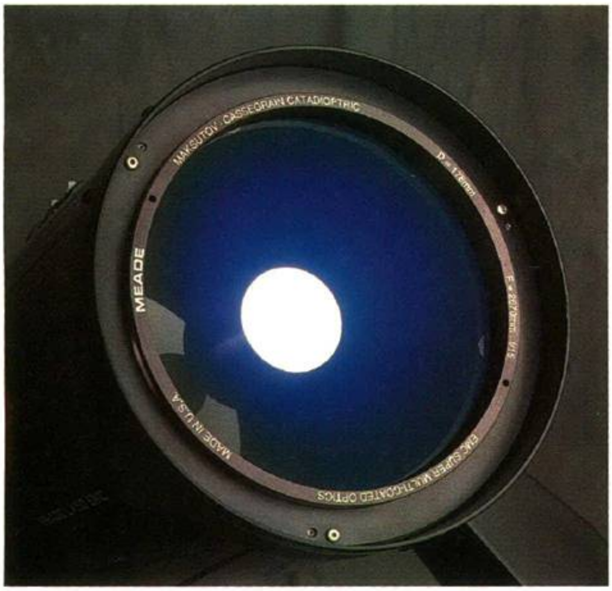
I'm somewhat concerned by the declination motor's exposed plastic drive gears. They sit on the forward, right side of the fork. I'd be more at ease if they were enclosed in some sort of cover to protect them from wear and tear. The fact that the gears are plastic didn't bother me as much as their vulnerability.

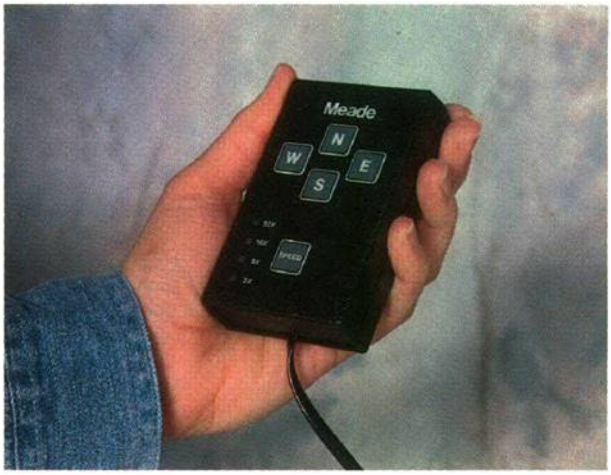
Tube and Optics

One feature that the 7-inch Mak-Cass has that's not found on many other commercial, closed-tube scopes is an internal fan to draw heat out of the tube assembly. If you are moving the scope between areas of different temperature, operating this fan reduces the time it takes the tube assembly to reach ambient temperature.

Of course, you could just let the scope cool down naturally, but its closed tube would make the process a slow one. Running the fan for about 30 minutes after taking the scope from a heated room to outdoor temperatures well below zero was more than enough time to cool it down.

Unlike its cousin the Schmidt-Cassegrain, the Maksutov-Cassegrain reflects light back to the eyepiece with an aluminized spot on its corrector plate.





A hand-controller adjusts the telescope's direction. N moves the scope up; S, down; E to the left; and W to the right. The lowermost button toggles both drives through different slew speeds.

The fan only runs when its power cord is plugged into the main console. I noticed that running it while observing set up image-distorting air currents inside the tube. It also caused slight vibrations in the telescope's field of view.

After the scope reached an ambient temperature of –10° F, I tested its optics by looking at the bright star Rigel through a 133-line-per-inch Ronchi screen. Such a test gauges a mirror's quality by breaking a star's light into a series of bright and dark bands. With a good mirror, the bands remain consistently parallel and undistorted through either side of focus. If there are any defects in the optic, these bands will appear distorted in some way, depending upon the optical imperfection.

Careful scrutiny of the image in this 7-inch Mak-Cass revealed a near-perfect set of parallel lines on either side of focus. If anything, the optic displayed an insignificant hint of undercorrection, more a testament to the precision of this type of test.

But the real test rested with how images looked through a high-power eyepiece. Viewing Auriga's 2nd-magnitude star Menkalinan at 380x revealed a clean, sharp Airy disk surrounded by two diffraction rings. I hardly noticed the glare from a waxing gibbous moon in nearby Taurus, thanks to coatings on the scope's front corrector plate.

Buying into the Package

So what do you get in a Meade 7-inch f/15 Mak-Cass? Exceptional optics, a choice of mounts, and a toehold on a system that includes CCD cameras and autoguiders. In this way, Meade is like camera manufacturers Canon or Nikon in that they offer a variety of foundation products you match up with specialized accessories they or other manufacturers offer.

In this particular case, Meade promises excellent optics that deliver what observers have traditionally looked to refractors for: higher-magnification views with a larger image scale. The 7-inch Maksutov-Cassegrain does this, and in a compact package that offers a telescope enthusiast plenty of room to grow. ☐

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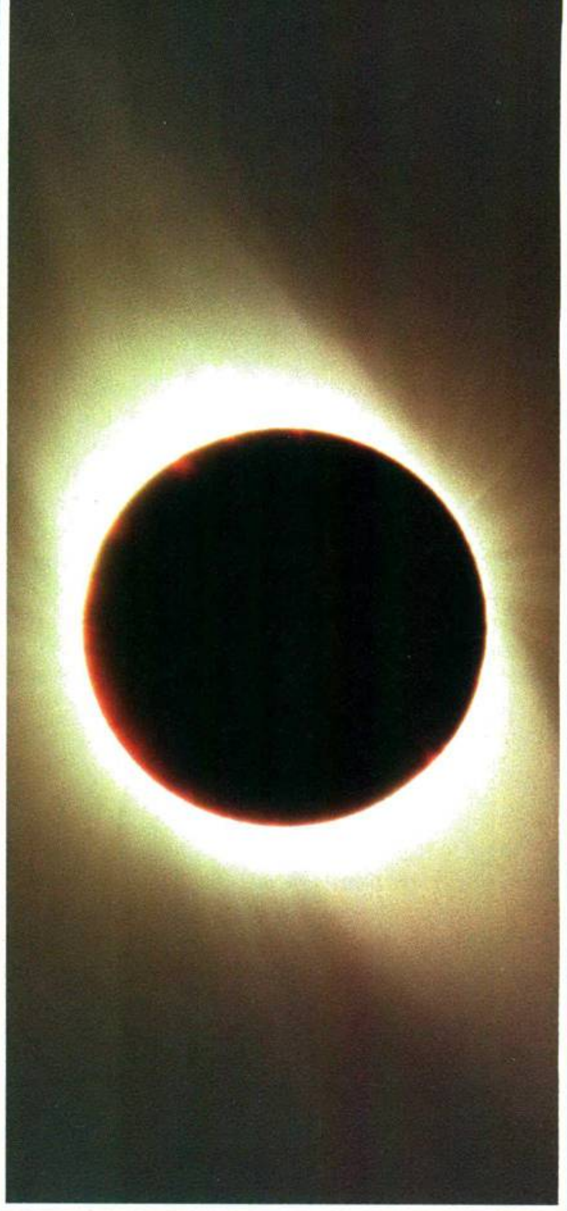

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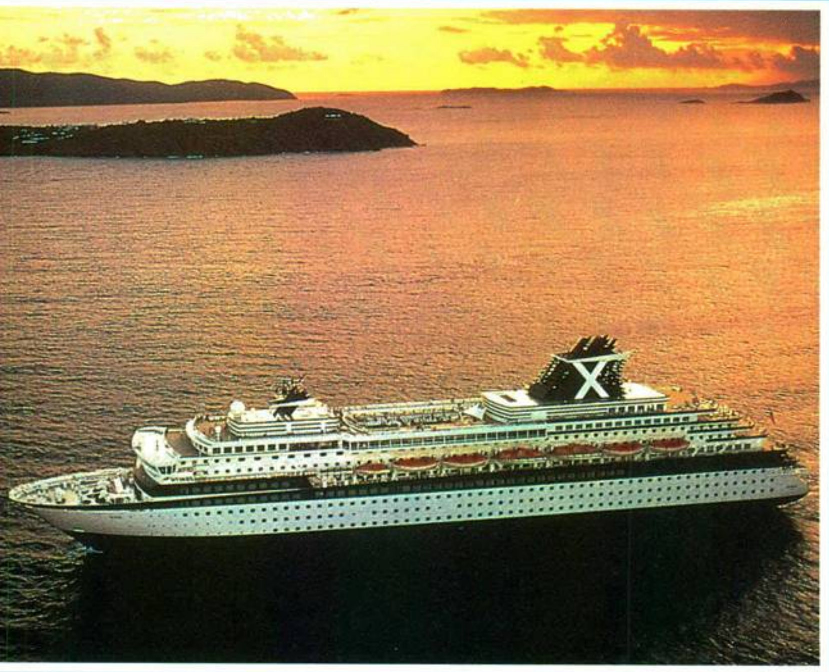

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Eclipse photo taken by Ernest Piini.

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Premium-grade SkyView telescopes offer an unsurpassed blend of performance, quality, and value. They're designed for the more serious beginning or intermediate-level amateur astronomer. Advanced optics are complemented by the renowned SkyView equatorial mount and rock-stable aluminum tripod with accessory tray. The mount features a rigid German-type head with dual 360° slow-motion gears, flexible cable controls with oversized barrel knobs for effortless tracking, barrel-type right ascension and declination lock knobs, and counterweight. A separate latitude adjustment aids in polar alignment.

SkyView™ 4.5" Equatorial Reflector
The aluminized and overcoated 4.5" primary mirror is mounted in a fully adjustable mirror cell, housed in a seamless aluminum optical tube. Secondary mirror is mounted on a three-vane adjustable spider. Smooth 1.25" rack-and-pinion focuser; optional electric focuser (*#2363*) available. Includes achromatic 6x30 finder scope with double-ring mounting bracket and TWO fully coated 1.25" Kellner eyepieces: 25mm (36x) and 9mm (100x). Focal length 910mm, f/8.
#9071 $399 (32.02)

SkyView™ 90mm Equatorial Refractor
Its multi-coated 90mm achromatic objective lens yields vivid images, collecting 125% more light than 60mm objectives. The long 1000mm focal length (f/11) provides the high magnification so desirable for viewing the planets. Seamless aluminum optical tube, smooth 1.25" rack-and-pinion focuser, and wide-field 6x30 achromatic finder scope with double-ring mounting bracket. Includes 1.25" star diagonal and TWO 1.25" Kellner eyepieces: 25mm (40x) and 9mm (111x).
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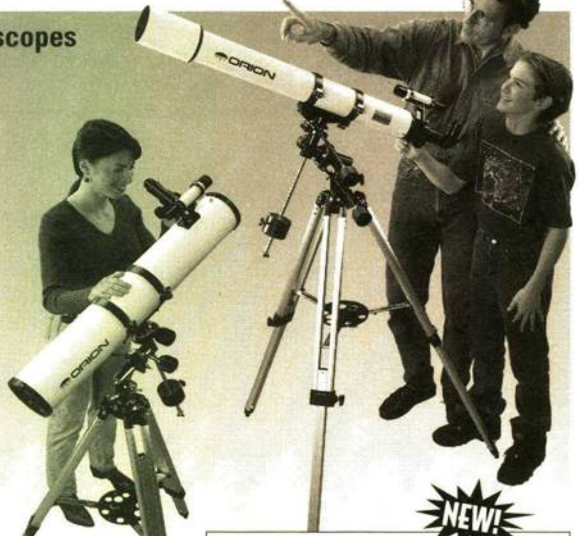

NEW!

AccuTrack™ DC Clock Drive
Enjoy automatic, hands-free star tracking with this accurate right ascension drive. Designed just for the SkyView equatorial mount, it's a snap to install and runs on one 9-volt DC alkaline battery.
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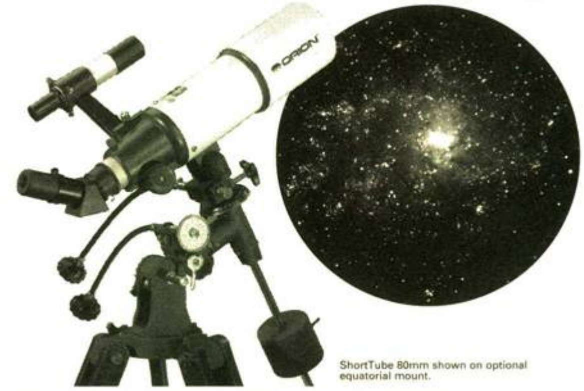
ORION



ShortTube 80mm shown on optional equatorial mount.

ShortTube™ 80mm Rich-Field Refractor

Rich-field 400mm f.l., f/5 scope that's great for observing and prime-focus astrophotography. Features a fully coated achromatic 80mm objective lens, 6x30 finder, 1.25" rack-and-pinion focuser, 45° erect-image diagonal, and TWO 1.25" Kellner eyepieces: 25mm (16x) and 10mm (40x). Attaches to any photo tripod or to Orion equatorial mount (sold separately). Optional carrying bag available.
#9086 $249 (9.22)

Ranger 70mm Refractor

The highly portable Ranger is no stay-at-home scope; it goes where you go. It combines a 70mm ED-glass achromatic objective and 480mm focal length (f/6.8) with a rugged, all-metal body. Includes helical focuser, mirror diagonal, and a 20mm (24x) Plössl eyepiece (1.25"). Ivory finish.
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Field Flattener #8780 $99 (4.54)

Camera Adapter #7425 $43.50 (3.86)

Tele Vue

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Field Flattener & Camera Adapter

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For the intermediate or advanced observer who seeks a large-aperture telescope with absolutely first-class features top to bottom, Orion's Premium DSEs are it. They feature hand-figured, diffraction-limited Pyrex mirrors with enhanced aluminum optical coatings boasting 94% reflectivity, instead of the industry-standard 86%, for brighter images. Also, durable Sonotube optical tubes, Ebony Star Formica and teflon bearings for buttery smooth movement, heavy-duty 4-vane secondary mirror support, and unique optical tube handles that allow easy lifting and transport.

Sizes:

10" aperture, 1422m focal length (f/5.6)
12.5" aperture, 1524mm focal length (f/4.8)
16" aperture, 1828mm focal length (f/4.5)

COMES WITH HIGH-QUALITY 26MM PLÖSSL EYEPIECE (1.25") AND YOUR CHOICE OF FOCUSER!

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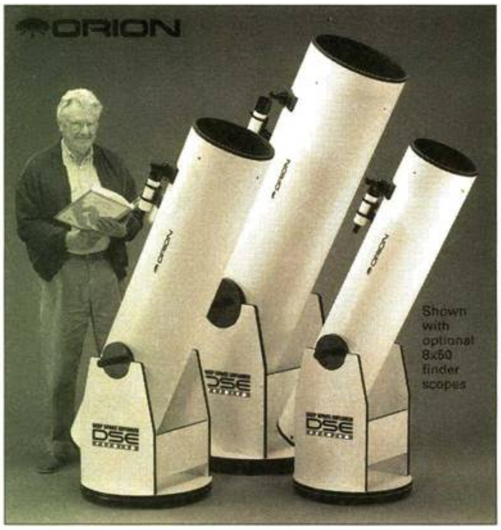

Shown with optional 8x50 finder scopes

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10"	#9913 $799	#9922 $819	#9919 $859	#9916 $899	(69.00)
12.5"	#9914 $969	#9923 $989	#9920 $1029	#9917 $1069	(79.00)
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Fully multi-coated Ultima 1.25" eyepieces are hybrid designs of 4 to 7 lens elements with blackened edges. All are threaded for filters, have rubber grip rings and rubber eyecups. Apparent fields: 51° (7.5-24mm), 50° (5mm, 30mm), 49° (35mm), 36° (42mm).

5mm	#8670	$89	(4.54)
7.5mm	#8672	$78	(4.54)
12.5mm	#8673	$83	(4.54)
18mm	#8674	$93	(4.54)
24mm	#8677	$99	(4.54)
30mm	#8678	$106	(5.26)
35mm	#8679	$119	(5.26)
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The highest contrast, light transmission, and image fidelity obtainable. Superior 5- or 7-element design with Ultra™ Multi-Coatings on every surface and blackened lens edges. Wide 52° apparent field. Removable winged rubber eyeguard blocks stray light and helps position your eye. Threaded for filters. 1.25" barrels.

3.8mm	#8576	$89	(4.54)
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7.5mm #8572, **10mm** #8570, **15mm** #8568, **20mm** #8566,		$79 each	(4.54)
25mm	#8564	$89	(4.54)
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Sirius™

FANTASTIC FULLY COATED EYEPIECES AT AN INCREDIBLY LOW PRICE!

NEW! NOW AVAILABLE IN .965" BARRELS

You could pay twice the price for other brands of Plössl eyepieces, but why? Sirius Plössls are top-quality, 50° apparent-field (43° 40mm) eyepieces that yield extremely sharp images of impressively high contrast. Ideal for all types of telescopes. The fully-coated optics are mounted in black-anodized aluminum housings with chrome-plated brass barrels for durability and precision fit. Rubber eyeguards. Stock up today!

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$49.95 each (3.86)
32mm, 40mm $59.95 each (3.86)

.965" Sirius Plössl
7.5mm #8541, **10mm** #8542, **12.5mm** #8543, **17mm** #8544, **20mm** #8545, **26mm** #8547
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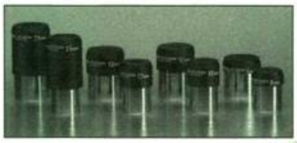
32mm, 40mm not available in .965"

Orion Explorer II™ Eyepieces

Reliable Performance, Remarkable Value!



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25mm #8150, **17mm** #8154, **13mm** #8151, **10mm** #8152, **6mm** #8153
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.965" Explorer II
25mm #8130, **17mm** #8154, **13mm** #8131, **10mm** #8132, **6mm** #8133
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With a 5- to 7-element lens configuration that yields a luxurious 65° apparent field, these eyepieces offer truly heavenly views. Super-Multi-Coated (SMC) with long 22mm eye relief.

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14mm 1.25"	#8223	$279	(6.14)
21mm 1.25"	#8224	$279	(6.14)
28mm 1.25"	#8225	$289	(6.14)
40mm 2"	#8226	$319	(6.62)

Tele Vue Plössl Eyepieces

Fully multi-coated, 50° apparent field (43° for 40mm).

8mm 1.25"	#8374	$85	(4.54)
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15mm 1.25"	#8372	$85	(4.54)
20mm 1.25"	#8371	$98	(4.54)
25mm 1.25"	#8370	$98	(4.54)
32mm 1.25"	#8329	$119	(5.26)
40mm 1.25"	#8327	$119	(5.26)
55mm 2"	#8328	$244	(7.02)

We also carry Tele Vue Panoptic and Nagler oculars. See our catalog.

ACCESSORIES

ORION

Barlow Lenses

Double or even triple the power of your eyepieces, maximizing the versatility of your collection.

Fully Baffled 2x Barlow
Multi-coated for highest transmission.

.965" 2x Barlow	#8740	$39.95	(4.54)
1.25" 2x Barlow	#8746	$49.95	(4.54)
2" 2x Barlow	#8724	$89.95	(4.54)

VariPower 2x–3x Barlow
Adjusts to any magnification between 2x and 3x. Fully multi-coated optics. 1.25" barrel.
#8748 $69.95 (4.54)

Shorty™ 2x Barlows
About half the length of our regular barlows for added convenience. Work in all scopes, including those in which longer barlows won't work.

.965" Shorty	#8710	$49.95	(4.54)
1.25" Shorty	#8711	$49.95	(4.54)

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6-Piece Optics Cleaning Kit

Includes compressed air, Ultra Brush, cleaning fluid, two books lens tissue, and cotton swabs.

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f/6.3 Reducer/Corrector

Provides a wider, flatter field of view

"Speeds up" f/10 Schmidt-Cassegrains to f/6.3, for wider field of view. Remarkable field flatness. Cuts exposure times for astro-photography. Fully multi-coated.

List $206 #5120 $144 (5.26)

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DeepMap 600™

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The Deep-Sky "Road Map" for Amateur Astronomers

- Giant 32" x 18" folding color star map by Wil Tirion
- Shows the 600 BEST celestial objects to view
- Includes listing of coordinates and visual info for all 600 objects
- Folds up like a road map to pocket size.
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Introducing the most convenient and innovative observing guide for telescope and binocular users! **Orion's DeepMap 600** shows the positions of 600 of the finest celestial objects visible from the Northern Hemisphere. Includes 500+ galaxies, nebulas, and star clusters, and 100 interesting double and variable stars. No other single star chart includes so many objects! Best of all, it folds up like a road map to pocket size!

No longer do you have to fumble with bulky star atlases and reference books to find fascinating objects to view. The quick-reference **DeepMap 600** is all you need. Perfect for beginning through advanced stargazers. Get yours today!

#4150 $12.95 (2.73)

Portable DC Power Station

NEW!

Compact, rechargeable battery provides 12-volt DC power for running your telescope's clock drive and other electronic accessories in the field. 8-amp/hour, sealed lead-acid design, completely maintenance free. Has dual 12-volt outlets and voltage meter. Recharges from 12-volt DC or 110-volt AC adapters (both included). Great low price! Weighs 9.5 lbs.

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RedBeam™ LED Flashlight

Astronomically correct red LED preserves dark adaptation. Shock-proof yellow plastic body is easy to find in the dark. Two AA batteries INCLUDED. #5744 $11.95 (3.41)

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Surveying the starry skies with a Mini Giant binocular is an experience you'll want to enjoy again and again. These high-quality binoculars will provide grand views, offering wide apertures for excellent light-gathering power, moderate magnification, and a generous field of view.

Mini Giant binoculars bridge the gap between traditional 7x50 "night glasses" and larger 70mm and 80mm "giant" models. BAK-4 porro prisms and fully multi-coated optics deliver the highest degree of light transmission and contrast.

Orion Mini Giants are easily hand-holdable, and threaded for tripod mounting. They feature smooth rubber armor for a good grip, a large knurled center focus wheel, and fold-down rubber eyeguards. Eye relief is a comfortable 18mm. Includes hard case, lens caps, and Orion's Deluxe Wide Neck Strap.

8x56 Mini Giant
Lighter and smaller than the 9x63 model. 8x magnification, 5.8° field of view, 7mm exit pupil. Weighs 32 oz.
#9361 $199 (6.62)

9x63 Mini Giant
Slightly higher 9x magnification, 5.0° field of view, 7mm exit pupil. Weighs 36 oz.
#9363 $239 (7.02)

Fujinon 7x50

SALE!

Great Low-Light Performance

Fully EBC multi-coated optics and BAK-4 prisms yield extremely high 95% light transmission, a very flat image plane, and long 23mm eye relief. These binoculars also feature a 7.5° field of view, 12' close focus, and individual eyepiece focus. What's more, they U.S. military specs and are 100% waterproof! Tripod adaptable. Includes strap and lens caps. Weighs 53 oz. Lifetime limited warranty. Case sold separately.

7x50 FMTR-SX (pictured)
Rubber covered, with leashed lens caps.
List $980 #52451 ~~$599~~ $469 (8.86)

7x50 FMT-SX
Coarse grain finish, without rubber armor.
List $880 #52448 ~~$549~~ $429 (8.86)

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Fujinon 70mm Polaris

Awesome Astro Binoculars

Flat-field optics reduce distortion and astigmatism to virtually undetectable levels. BAK-4 prisms and EBC multi-coatings. Waterproof, tripod adaptable. Individual eyepiece focus.

SALE!

10x70
5.2° field of view, long 23mm eye relief, 10x magnification. Weighs 4.8 lbs.
List 1080 #52449 ~~$675~~ $529 (9.81)

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4.0° field of view, 12.4mm eye relief, 16x magnification. Weighs 4.8 lbs.
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Legacy 10x50 WA	*List $203*	#52391	$144	(6.23)
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NIKON

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ORION

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PENTAX

PCFIII 7x50	*List $255*	#52255	$169	(6.23)
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SWIFT

Observer 11x80	*List $670*	#52030	$379	(9.13)

Dozens more binoculars in our printed and online catalogs!

ORION

Orion 50mm Scenix™

High-Quality Binoculars at a Remarkably Reasonable Price

Value-minded observers will appreciate these reliable yet highly affordable field glasses. Every air-to-glass optical surface is antireflection coated, and the objective lenses are multi-coated. Sturdy metal housing, not plastic. Tripod adapter socket.

7x50 Great for binocular astronomy as well as for scenic daytime viewing. Bright 7mm exit pupil and a 7.1° field of view. Weighs 28 oz. #9342 $96 (5.38)

10x50 Uncommonly wide 7° field of view for a 10x binocular. Weighs 28 oz. #9343 $96 (5.38)

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EXTRA-LONG EYE RELIEF!

Orion 50mm UltraView™

Best Bino Available For Eyeglass Wearers

Extra-long 22mm eye relief and unique pop-down eyeguards. Fully multi-coated. BAK-4 prisms. Close focus 16'. Tripod adaptable. Weighs 32 oz.

7x50 Best for wide-field deep-space astronomy and nighttime surveillance. 6.5° field of view. #9357 $188 (6.23)

10x50 Highest power model, well suited for astronomical observation and distant terrestrial viewing. 6.5° field of view #9351 $188 (6.23)

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Orion 50mm Vista™

Featherlight High-Performance Binoculars

Vistas feature high-index BAK-4 prisms and fully multi-coated optics for high-fidelity images. Lightweight metal alloy bodies with cushioned leatherette covering. Tripod adaptable. Weighs 28 oz.

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8x56, 9x63 Ultima®

Scanning the night sky is a treat with these better-quality binos. Fully multi-coated, BAK-4 prisms, 21mm eye relief. Tripod adaptable.

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9x63 5.4° field, 35 oz. #9542 $349 (7.42)

Pro Series

A popular choice for those who want a good binocular at a reasonable price. Fully multi-coated optics with BAK-4 prisms. Tripod adaptable. Water-resistant, textured covering.

8x40 Wide 8.2° field, 18mm eye relief, 15' close focus. Weighs 27 oz. *List $280* #9593 $177 (6.23)

7x50 7.1° field of view, bright 7mm exit pupil, extra-long 23mm eye relief, 21' close focus. Weighs 29 oz. *List $280* #9588 $169 (6.23)

10x50 6.5° field of view, 5mm eye relief, 5mm exit pupil, 30' close focus. Weighs 30 oz. *List $280* #9590 $169 (6.23)

8x56 5.8° field of view, 7mm exit pupil, 18mm eye relief, 30' close focus. Weighs 34 oz. #9670 $219 (6.62)

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70mm Little Giants™

The standard for hand-holdable astronomy binoculars. Fully multi-coated. Terrific brightness and edge sharpness! Weigh 58 oz. Include tripod adapter and deluxe hard case.

10x70 #9501, **14x70** #9494 $369 (8.20)

80mm Giant Binoculars

Jaw-dropping views of the heavens and Earth. Fully multi-coated optics and BAK-4 prisms provide fantastic contrast and brightness. Includes tripod L-adapter, and deluxe hard case. Each model weighs 4 lbs., 13 oz.

11x80 Ideal for deep-space observation under dark skies. Hand-holdable. Field of view 4.5°. #9502 $469 (9.13)

16x80 Excellent for astronomy and daytime observation.Tripod recommended. Field of view 3.5°. #9496 $469 (9.13)

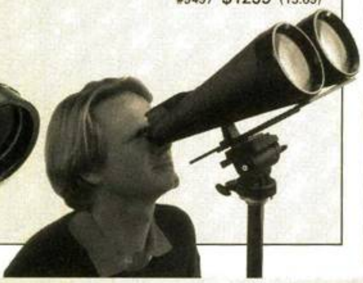
20x80 Highest-power model, perfect for smaller deep-space objects and long-range daytime views. Tripod required. Field of view 3.5°. #9498 $469 (9.13)

100mm SuperGiants™

Gigantic, nearly 4"-diameter lenses gulp in the light, gathering 56% more than 80mm binoculars. BAK-4 prisms and fully multi-coated optics for the sharpest, brightest possible images. Mounts on any standard tripod. Heavy-duty, metal case. Weighs 7.5 lbs.

14x100 Moderate 14x magnification and 7mm exit pupil are ideal for astronomical observation under dark skies. Individual eyepiece focus, rubber eyeguards. Field of view 3.3°. #9495 $1299 (15.69)

25x100 High-power 25x magnification and a 4mm exit pupil. Center focus, rubber eyeguards. Field of view 2.6°. #9497 $1299 (15.69)



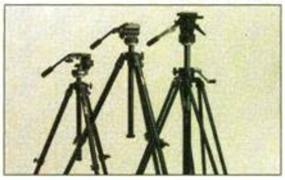
Bogen Field Tripods

Solid support for binos and spotting scopes. Extremely rigid cast-metal tensioned leg hinges for absolutely secure, wobble-free connections.

Standard Model Great for spotting scopes, cameras, small telescopes. Extends to 59" and folds to 25". Fluid pan head. #20703 $179 (3.95)

Heavy-Duty Model Perfect for larger "Mak" spotting scopes and heavy cameras. Extends to 63" and folds to 28". Heavy-duty fluid pan head with quick release. #20705 $209 (4.78)

Ultra Heavy Duty Model Double strut center-braced model for big optical tubes and the largest-format cameras. Extends to 73", folds to 39". Ultra-heavy duty pan head. #20709 $369 (5.29)



Binocular Tripod L-adapters

Attaches most any binocular to a standard camera tripod. Large model is ideal for binoculars over 50mm, small model for 50mm or smaller binoculars.

Large Adapter	#5250	$21.50	(2.43)
Small Adapter	#5252	$19.95	(2.43)

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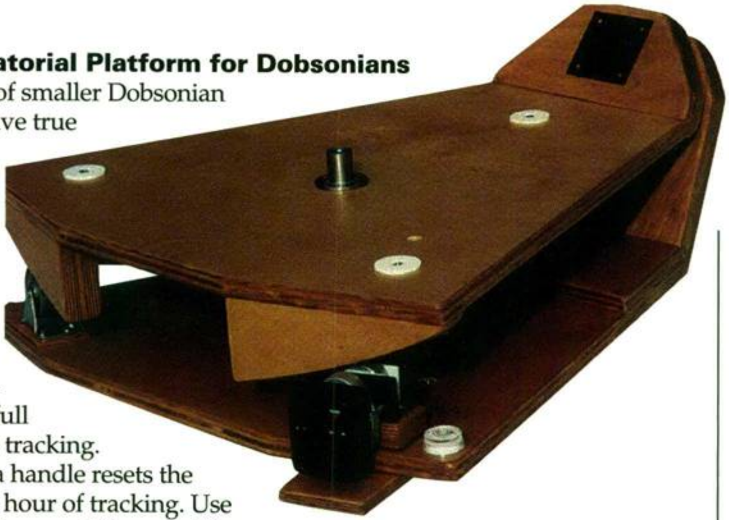
NEW PRODUCTS

Compact Equatorial Platform for Dobsonians



Now owners of smaller Dobsonian telescopes can have true equatorial tracking with no field rotation for an affordable price. The *Compact Equatorial Platform* gives any 6- to 12½-inch Dobsonian telescope a full hour of precision tracking. Then the pull of a handle resets the drive for another hour of tracking. Use your scope like always while everything you observe stays centered in the field of view. Use high powers at will, or let a whole line of people observe without recentering the scope's field of view. The platform weighs only 20 pounds but easily supports up to a 100-pound telescope and can be used with most popular brands of digital setting circles. It is made from cabinet-grade birch plywood with a multi-layered weatherproof finish. The direct roller drive runs on a single rechargeable 9V battery (included).

Equatorial Platforms, 11065 Peaceful Valley Road, Nevada City, CA 95959; phone, (916) 265-3183; e-mail, tomosy@nccn.net; website, http://www.Astronomy-Mall.com. *The Compact Equatorial Platform*: $850, plus crating/shipping.

Optical Evaluation Eyepiece

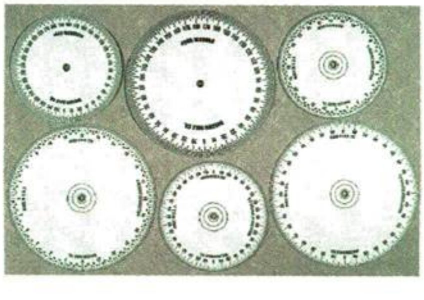
This 1¼-inch eyepiece allows you to evaluate the optical quality of any reflecting telescope's main mirror. *Easytester* slips into the focuser and uses a built in 133-line-per-inch Ronchi screen to break a bright star's focused light into a series of parallel lines. How parallel and smooth those lines appear slightly either side of focus reveals the quality of the main mirror. The standard *Easytester* has a brass tube with black plastic eyecap; the classic version is all-brass. Both come with a lifetime warranty.

Jack Schmidling Productions, Inc., 18016 Church Road, Marengo, IL 60152; phone, (815) 923-0031; fax, (815) 923-0032; e-mail, arf@maxx.mc.net; website, http://dezines.com/@your.service/jsp/. Standard *Easytester:* $29; Classic *Easytester:* $79. Add $4 for shipping.

Setting Circles

The Oregon Rule Company offers 6-inch or 8-inch diameter declination and right ascension circles for homemade telescopes. The circles come printed with black characters on a white background and are sealed with a 5-mil-thick Mylar coating. Right ascension dials feature a 24-hour scale in 2-minute steps; declination goes from 0° to 90° in 1° increments. An adhesive back lets you attach the circles to any surface.

Oregon Rule Company, P.O. Box 5072, Oregon City, OR 97045; phone, (503) 657-8330; fax, (503) 655-8040. Six-inch diameter setting circles: $9.50 each; 8-inch diameter setting circles: $10.50.



Stationary Telescope Pier

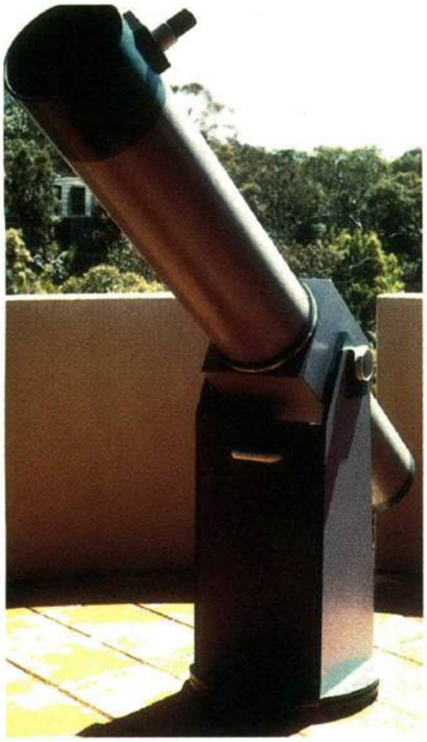
Le Seur Manufacturing Company offers a pier kit that lets you install a telescope mount permanently into the ground. The kit has two parts: a pier mounting plate, which sinks 4 feet into the ground, and a pier, which bolts to the plate. Quarter-inch rebars under the mounting plate secure the assembly in a hole filled with concrete. Three-quarter-inch bolts both accept the pier and allow you to level it. The pier itself is made from ¼-inch and ⅜-inch welded steel. You specify what size scope and type of mount when ordering. Standard sizes accommodate 6-, 8-, 10-, and 16-inch telescopes. Custom sizes are available at an extra charge. Piers come in midnight blue, black, or white.

Le Seur Manufacturing Company, Inc. 3220 Lorna Road, Birmingham, AL 35216; (205) 822-0720; fax, (205) 822-0749. Telescope Pier Kit: $225.

CCD Conference on Video

This seven-volume set of video proceedings comes from a two-day conference that explored CCD cameras, autoguiders, and imaging software. Frequent ASTRONOMY magazine contributor Tony Hallas tells how to tune an autoguider for better astrophotographs. Astrophotographers Benoit Schillings and Brad Wallis detail their novel use of an autoguider to compensate for unsteady atmospheric seeing during an exposure. John Stull of Alfred University explains how to measure binary star light curves. Other speakers discuss CCD camera control techniques and trends within the hobby.

Take One Video Productions, c/o Keith Gaskins, SBIG, P.O. Box 50437, Santa Barbara, CA 93150; phone, (805) 969-1851; fax, (805) 969-4069; e-mail, sbig@sbig.com. *The 1996 CCD Imaging Conference Video*: $99 plus $5 shipping.



Telescope Construction Kit

Australian telescope maker Ron Royle sells materials and plans to grind a mirror for and assemble an 8-inch f/10 telescope. The telescope kit contains a blank, a mirror-grinding tool, grinding compounds, lap material, polish, a sagitta gauge, a Ronchi test screen, parabolizing software for a PC computer, and detailed instructions. The telescope tube and rocker box ship in sections for you to assemble. You provide the finderscope, eyepiece, and aluminizing for the primary mirror. Mirror kits are available separately.

Build Your Own Telescope, 40 Russell St., Watsons Bay, New South Wales, 2030, Australia; phone, (011) 612-9337-5350. Complete Telescope Construction Kit: $US375; Mirror Kit: $US240. Freight costs are extra.

Constellation Jewelry

Gems of Light jewelers mount rhinestones into blue-gold stones to create your favorite constellation on pins, pendants, tie tacks, earrings, and cuff links. Choose from a set of zodiacal constellations, Orion, and the Pleiades, or specify your own area of the sky. Pendant chains, earring posts, and cuff links are made from sterling silver or gold-plated bezel.

Gems of Light, P.O. Box 40911, Philadelphia, PA 19107; phone (215) 563-8977; e-mail, lorriel@gim.net; website, http://GBK3.GIM.NET/GEMS. Pins: $30; pendants: $39.95; earring set: $22; cuff link set: $24; tie tacks: $15 (Pleiades only). Add $5.95 shipping and handing, plus appropriate state sales tax.

Brass Refracting Telescope

This 90 mm (3.6-inch) f/11 refractor features a lacquered brass tube fitted with a 6x30 finder scope, a wooden tripod, an accessory tray, and an equatorial mount. Slow-motion knobs let you keep objects centered in a 12.5 mm (73x) orthoscopic 1¼-inch eyepiece. Optional accessories include a moon filter, a clock drive, a 2x Barlow lens, a camera adapter, a polar finder scope, a sun projection screen, a 4 mm eyepiece, and an erecting image prism.

Swift Instruments, Inc., 952 Dorchester Ave., Boston, MA; phone, (617) 436-2960; fax, (617) 436-3232. Model 868 Brass Achromatic Refracting Telescope: $3,250.

CCD Flip Mirror and Filter Holder

This CCD accessory combines a flip-mirror for centering and focusing a CCD camera with a holder for different types of astronomical and photographic 1¼-inch filters. The unit comes with a protective filter wallet, five slides that hold one filter each, and two adapters for eyepiece projection or prime-focus photography. True Technology, manufacturer of *Filter-Finder*, also offers a set of dichroic red, blue, green, infrared block, and clear filters available in 1¼- or 2-inch sizes.

Adirondack Video Astronomy, 35 Stephanie Lane, Queensbury, NY 12084; phone, (888) 799-0107; e-mail, 72323.3043@compuserve.com; website, http://ourworld.compuserve.com/homepages/AVAstro. *The Filter-Finder:* $329.95; set of five dichroic filters: $179. Add $5 shipping and handling.

ASTRONOMY *assumes no responsibility for the product information supplied by manufacturers. Prices are retail and subject to change without notice. Suppliers should send announcements and color photographs to the attention of John Shibley, P.O. Box 1612, Waukesha, WI 53187, or newprod@astronomy.com.*

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Operate your telescopes ***anywhere!*** Use the single-axis Unitrak with a 12V DC car battery. The dual-axis drives are for photography and use either 12V DC or 125V AC.

Unitrak™ single-axis corrector	**$99.95**
Unitrak with hand controller	**$139**
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PENTAX 65° XL EYEPIECES

AMAZING performance! Full 20mm eye relief, adjustable helical eye guard, super multi-coating, 65° field.

Pentax 5.2mm, 20mm eye relief	**$279**
Pentax 7mm, 20mm eye relief	**$279**
Pentax 10.5mm, 20mm eye relief ...	**$269**
Pentax 14mm, 20mm eye relief	**$269**
Pentax 20mm, 1¼'', 65° field	**$269**
Pentax 28mm, 1¼'', 65° field	**$259**
Pentax 40mm, 2'', 65° field	**$299**

RICH FIELD! 2° in 8'' SCT

NOW ONLY
$99.50

LUMICON Rich-Field Viewer on C-8 with LUMICON 2'' star diagonal and 2'' eyepiece.

The LUMICON Rich-Field Viewer fits **all** commercial Schmidt-Cassegrain telescopes. It has a high-performance coated achromatic focal reducing lens with 50mm or 80mm clear aperture for **totally unvignetted viewing** with 2'' or 1¼'' eyepieces. It is available in several combinations depending on the eyepiece and field-of-view you desire (see chart below).

LUMICON Rich-Field Viewer	**$99.50**
Giant Rich-Field Viewer (10-14'') ..	**$250.00**

Optional Eyepiece	**TRUE FIELD**	**Price**
Meade 32mm Plossl	1.4°	**add $99**
Meade 32mm 2'' Wide-Field†	1.9°	**add $459**
Meade 40mm 2'' Wide-Field†	2.4°	**add $519**

†Includes 2'' enhanced aluminum Star Diagonal (may not reach focus on some telescopes).

PROTECTIVE DUST COVERS

Protect your valuable telescope optics, eyepieces and accessories with these black vinyl covers. Add $1 shipping. Deduct 10%, 2 or more sets.

1¼'' O.D. plug, seals focuser	**4/$2**		
2'' O.D. plug	**2/$2**	3½'' O.D. plug	**$1.50**
1¼'', 1⅜'' ...	**3/$2**	7½''	**$10**
1½''	**2/$2**	9½'', 10.4''*	**$15**
2''	**2/$2**	12½'', 12⅞''* ...	**$20**
2⅛''	**2/$20**	15.0'', 15.6'', 16''*	**$28**
5½''	**$6**	19'' (DS-16)	**$35**
*Fits Odyssey		21'' (Odyssey-II)	**$35**

MEADE 7'' - 16'' LX200
NEW! 7'' - 10'' LX50

8'' LX50
$1395

16'' LX200 $14,950

Meade 8'' LX200 Telescopes

LX50 - includes dec. motor, hand controller.
LX200 - full computer control w/64K obj. mem.
Tripod: extra for LX50; included for LX200
NOTE: A wedge is **not** needed for visual observing with the LX200 Drive. Select f/10 or f/6.3 (no extra charge) for your LX200.

NEW! 3.5'' f/14 ETX Maksutov ($20)	**$595**
Meade 2045D 4'' f/10 w/motor ($20 P&S)	**$699**
8'' LX10 w/wedge, hand controller ($65)	**$995**
Field Tripod for 8'' LX10 ($20)	**$195**
8'' LX50 w/wedge ($105 P&S)	**$1395**
Adj. tripod for 8-10'' SCT ($30 P&S) .	**$295**
8'' LX200 w/computer ($105 P&S) .	**$2795**
Wedge for photographing w/8'' LX200	**$139**
7'' LX50 f/15 Maksutov w/wedge ($125 P&S)	**$1795**
10'' LX50, f/10 w/wedge, dec. motor, hand controller ($145 P&S)	**$1695**
10'' LX200 w/computer ($145 P&S)	**$3195**
12'' LX200 (f/10 only)($215 P&S)	**$4495**
Super Wedge for photogr. w/10'',12'' LX200	**$395**
16'' LX200 f/10 w/tripod ($385 P&S) .	**$14,950**
Dew Shields: 8'' .... $119; 10''	**$129**
12'' .... $189; 16''	**$289**

PHOTOGRAPHY ACCESSORIES

Cassegrain EASY-GUIDER 4'', 8'', f/6 or f/10	**$249**
Giant EASY-GUIDER for 10''/12'' f/4-f/10 .	**$395**

MEADE STARFINDERS

8'' f/6
$749

New 8'' f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions. These are complete telescope systems with motor drive & finderscope (equat. only), mount, and 25mm (=48X) eyepiece. New DC motor runs on 4AA batteries.

6'' f/8 Dobsonian Starfinder ($46 P&S)	**$319**
6'' f/8 Equat. Starfinder 6(add $79 P&S) ...	**$649**
8'' f/6 Dobsonian Starfinder (add $59 P&S) .	**$419**
8'' f/6 Equat. Starfinder 8 (add $89 P&S) ...	**$749**
10'' f/4.5 Dobsonian Starfinder ($85 P&S) ..	**$599**
10'' f/4.5 Equat. Starfinder 10 (add $99 P&S)	**$879**
12.5'' f/4.8 Dobsonian Starfinder ($95 P&S)	**$895**
16'' f/4.5 Dobsonian Starfinder (freight COD)	**$1195**
16'' f/4.5 Starfinder 16 (ship. freight COD) .	**$2695**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing & shipping charge to the price. Slightly lower P&S for payment by check. LUMICON showroom prices are $50-$100 higher.

ACCESSORIES

LUMICON carries all Meade accessories.

LUMICON Single axis drive corrector .	**$99**
Magellan computer; specify Dob. or Eq. ($15 ship)	**$295**
Meade 47M Dual-axis drive corrector with tangent arm & electric declination ..	**$475**

SKY VECTOR™ $299!!

Includes Computer, Encoders, Hardware

LUMICON ACCESSORIES

LUMICON, Livermore, CA 94550 (510) 447-9570 FAX (510) 447-9589

LOW PRICE—from $299

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $299

NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $349

10,000 Objects! — Also includes Identify (Sky Tour) Function, planets and full visual descriptions.

NGC SKY VECTOR™ $439

12,000 Objects!— PC Serial Port

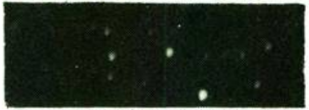
NGC-Sky Vector™
OFF ON
DIM
MODE
ENTER
UP
DOWN
LUMICON®

NGC SKY VECTOR with IDENTIFY (Sky Tour) mode, 12,000 object memory including the corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

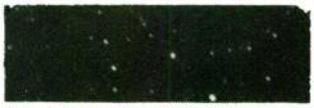
Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth, Meade 6-16'' Dobsonian.

Ultima 8, 9¼, 11 **add $25**, C-14 **add $75**

COMA CORRECTOR



Coma 1 inch off-axis 17½'' f/4.5



Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2'' lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2'' EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8''.

LUMICON 48mm Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2'' EASY-GUIDER .	**$189.50**
2'' EASY-GUIDER (Mamiya 645)	**$239.50**
2'' Adapter for Pentax 6X7 ...	**$129.00**
2'' Adapter for Hasselblad .	**$229.00**
2'' Adapter for Bronica SQ-A	**$175.00**
2'' Extension for viewing ...	**$26.00**

2'' DELUXE BARLOW

1.8x Multiplier Lens (2'' Barlow)

LUMICON 1.8x Multiplier Lens (2'' Barlow)	**$259.00**

LARGE UV/DUST SEAL

Protect the optics of your 8-14'' Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080 ...	**$119.50**
UV/Dust Deal for Celestron C-8 ...	**$39.00**
UV/Dust Seal for Meade 2080, 2045	**$39.00**
UV/Dust Seal (large) for Meade 2120	**$89.50**
UV/Dust Seal for Celestron-11, -14 .	**$89.50**

LOW PROFILE FOCUSERS
New! Thread-on for Odyssey

FROM $69.50

LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½'' above the telescope tube. Use the 1¼'' or 2'' versions for viewing. Use the 2'' non-rotating focuser for convenient photography with the LUMICON 2'' EASY-GUIDER™.

Select your desired base-plate shape!
Coulter Odyssey (thread-on installation), Flat, 7'' OD, 9½'' OD, 12½'' OD, 16'' OD, 21'' OD.

LUMICON 1¼'' Helical Focuser	**$69.50**
LUMICON 2'' Helical Focuser 1½'' high	**$75.00**
LUMICON Non-rotating Helical Focuser	**$129.00**
2'' Astro Systems focuser, only 2'' high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2''/1¼'' **adapter** w/48mm filter threads	**$20.00**
2'' **LUMICON EASY-GUIDER**	**$189.50**

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼'' 50mm Finderscope **$69.50**, 45°version	**$69.50**
1¼'' straight-thru 80mm SUPER-FINDER .	**$189.50**
1¼'' right-angle 80mm SUPER-FINDER ..	**$199.50**
1¼'' right-angle version, w/star diagonal ..	**$239.50**
25mm Cross-hair 1¼'' eyepiece (12X)	**$59.00**
Large mounting rings for 80mm Finder	**$55.00**
1¼'' Star Diagonal **$49**, Mounting Brackets,	**$39.50**
1¼'' 45° diagonal for correct left-right views	**$59.50**

LOTS OF ADAPTERS

2'' adapter for C-8, Meade 2080, etc. ..	**$29.50**
2'' adapter for C-80, C-100 refractor ...	**$39.50**
2'' adapter for C-70, C-80F, C-100F fluorite	**$39.50**
2'' adapter for C-6, Comet Catcher, Meade 312	**$30.00**

EXTENSION TUBES

1'' long 1¼'' OD thread-in extension ...	**12.00**
2½'' long extension (holds 1¼'' filters) .	**19.50**
4½'' long extension for 1¼'' eyepieces	**$29.00**
3'' long extension for 2'' eyepieces* ..	**$29.00**
2'' long extension for 2'' eyepieces* ..	**$29.00**

VIEWING ADAPTERS

2''/1¼'' reducing bushing,threaded 48mm*	**$25.00**
2''/T-thread adapter, threaded 48mm* ..	**$25.00**
T-thread/1¼'' adapter	**$25.00**
F/10 2'' or 1¼'' eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2'' Diagonal/Giant Easy-Guider	**$39.50**

**Threaded to hold 48mm filters.*

WRITE NO. 6 ON THE READER SERVICE CARD

Meade & Celestron
LUMICON carries a full line of telescopes and accessories. Fast Delivery. Competitive Prices

LUMICON FOR HIGH PERFORMANCE

Visit our LUMICON web-site: http://www.rahul.net/Astro-Mall

NEW LUMICON MULTIPLE FILTER SELECTOR

$129

ALWAYS GET THE BEST VIEW!

$99
(If ordered with filter or filter set)

The New LUMICON Multiple Filter Selector holds up to 5 1¼" LUMICON filters. The sliding bar has a click-stop at each filter position. Now you can instantly select the best filter for any deep-sky object. Cost is $129 or $185 with 1.5X relay lens (for Newtonians). **Save $30 if ordered with filter(s)!**

TELE VUE™

NEW! Bino Vue Binocular Viewer

Genesis-SDF 4" f/5.4 apochromat	$1950
Pronto 70mm f/6.4 apochromat w/2" diagonal	$939
Pronto 70mm f/6.4 w/45° erecting prism	$789
NEW! Bino Vue binocular viewer	$899
Gibraltar mount with ash wood tripod	$495
10.4, 26mm Plossl 50°	$79
8, 11, 15mm Plossl . **$89**, 20, 25mm	$99
32mm Plossl, widest true field in 1¼"	$119
55mm 2" Plossl, widest possible field	$229
2.0x or 3.0x Tele Vue Barlow Lens	$115
2" Giant Barlow - 2x	$179
15mm Wide-Field, 1¼" eyepiece, 65°	$139
4.8mm Nagler, 82° field, 1¼" eyepiece	$169
7mm Nagler, 1¼" eyepiece, 82° field	$219
9mm Nagler, 82° field, 1¼" or 2"	$239
13mm Nagler, 82° field, 1¼" or 2"	$299
12mm Nagler, Type II, 82°, 1¼"/2"	$279
16mm Nagler, Type II, 82°, 1¼"/2"	$299
20mm Nagler, Type II, 82°, 2" only	$375
2" Paracorr Visual Coma Corrector	$249
15mm Panoptic 1¼", 68° field	$209
19mm Panoptic 1¼", 68° field	$245
22mm Panoptic 1¼"/2", 68°	$269
27mm Panoptic 2", 68° field	$319
35mm Panoptic 2", 68° field	$349

TeleVue Warranty may not be valid outside USA.

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.
LUMICON Adjust. Piggyback Mount $59.50
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the LUMICON Deep-Sky (DS) Filter.

Specify Lens Size	**H-Alpha**	**(DS)**
46, 48, 49mm	$59.00	$199.50
52, 55, 58, 62mm	$69.00	$199.50
67, 72, 77mm	$79.00	$399.50
82mm (77mm + adapter)	$89.00	$415.00

Hypered 2415 film, 36 exp .. **$11.95, $3/$32**

LUMICON®
2111 Research Dr. #5A, Livermore, CA 94550
For phone orders please call (510) 447-9570
FAX (6 PM-9 AM PST) (510) 447-9589
LUMICON Products catalogue FREE
All foreign orders add 8% ($10 minimum)
California residents add 8.25% tax.
Prices subject to change w/o notice.
Hrs: M-F 9 am - 5 pm, Sat. 9 am - 1 pm

NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	**$39.50**	1.52"	**$45.00**	1.83"	**$49.50**
2.14"	**$59.50**	2.60"	**$75.00**	3.10"	**$99.50**

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	**$99.50**
2" (1.83" mirror)(see photo above)	**$189.50**

LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON O-III proved to be our favorite... It gave the greatest contrast gain."
ASTRONOMY, **February 1991**

AMAZING O-III FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

GREATLY ENHANCED DETAIL

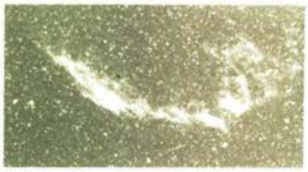
"Consistently performed well on all emission and planetary nebulae. Detail and structure were greatly enhanced in the more than two dozen objects I viewed." ***SKY & TELESCOPE***, **July 1995**

BETTER THAN A DARK-SKY SITE!?

"From my light polluted backyard, the view ... was better with the O-III than with any other filter tested. The view was even better than without the filter from a dark-sky site." ***SKY & TELESCOPE***, **July 1995**

SEE THE HORSEHEAD!

*"**LUMICON's H-Beta Filter** will show subtle features in emission nebulae that the others fail to reveal. It can't be beat for the elusive Horsehead and California nebulae. . ."* ***SKY & TELESCOPE***, **July 1995**



"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!

"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!

*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."* ***ASTRONOMY***, **February 1991**

	Premium*
0.96" LUMICON DEEP-SKY Filter threads into most 0.96" eyepieces	$59.50
1¼" LUMICON DEEP-SKY Filter threads into most 1¼" eyepieces	$99.50
48mm LUMICON DEEP-SKY Filter (1.7" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS	$199.50
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	$199.50
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $10, 82mm $16)	$399.50
2" Rear Cell Filter, fits SCT's ... Deep-Sky, **$199.50** UHC, O-III, H-Beta,	$199.50
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	$99.50
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	$199.50
Choice of ***any two*** LUMICON filters (**Save 7%**) ... 1¼" **$185.00**; 48mm	$370.00
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** ... **$99.50, 48mm**	$199.50
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines ... **1¼" $99.50; 48mm**	$199.50
LUMICON Comet (Swan band) Filter ... **1¼" $99.50; 48mm**	$199.50
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm	$7.95
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	$19.50
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	$25.00

**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**

MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT **$75**

Electric Vacuum Pump, Model R-10 **$325**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars. †U.S. Patent 4,448,500
Specify Camera and Telescope type.

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	**$189.50**
48mm Coma corrector/field flattener	**$285**
3X Relay Diagonal (see photo)	**$99.50**
Illuminated reticle eyepiece, pulsed	**$109.50**

Guider for Hasselblad **$409,** Mamiya 645 **$199**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$249.00**
Adapter for Hasselblad **$225,** Mamiya 645 **$98**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10-12" Meade. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) ..... **add $99.95**
Adapter for Hasselblad **$295,** Mamiya 645**$149**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

WHAT DO YOU NEED?

1. **Illuminated reticle eyepiece** ... **$109.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, pulsed.

2. **Cable release** for long exposures **$9.95**

3. **Declination motor** (state telescope type) **$109**

4. **Dual-axis drive corrector** for telescope. This should be part of the telescope when purchased. Call LUMICON for details.

5. **LUMICON EASY-GUIDER** (selection to left)

6. **LUMICON 48mm DEEP-SKY FILTER $199.50**
This is essential for highest possible contrast. Contrast is boosted up to 3X for ***both*** color or black & white photos. The 3 photos in this ad showing the Helix Nebula, Horsehead Nebula and Veil Nebula were all made using a LUMICON 48mm DEEP-SKY FILTER.

7. **Hypersensitized film.** Purchase from LUMICON or make your own with a LUMICON HYPER-KIT.

TRY PPF!
HYPERSENSITIZED FILM

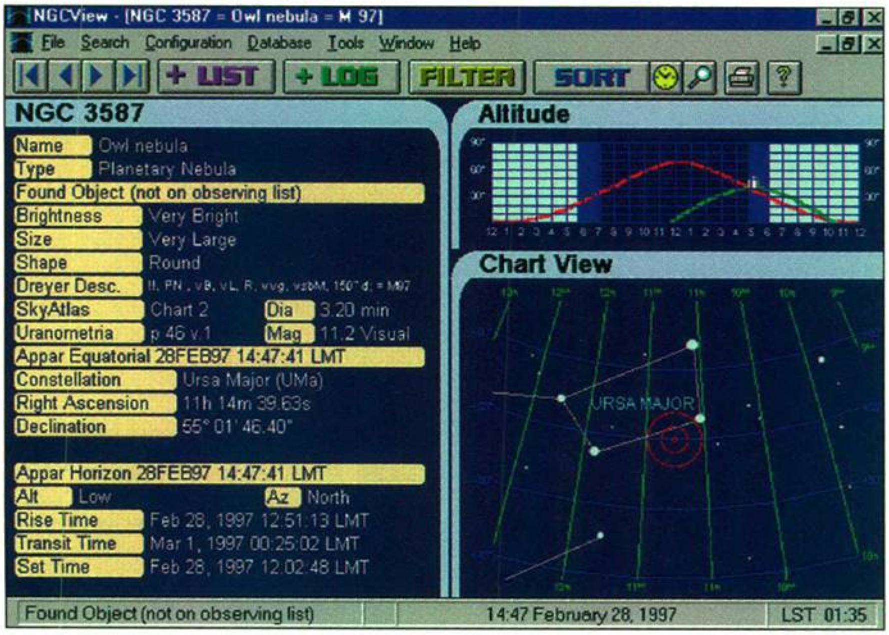
HYPERED FILM IS 2-10X FASTER!

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	**Exposures**	**Price**
Kodak PPF-400, THE BEST!	36	**$14.95**
2415, Ultra-fine B&W, red sens.	36	**$11.95**
SR-G3200, fastest of all, color neg	24	**$13.95**
Kodak Gold 1000 fast, fine grain	12	**$13.95**
Fuji G800 fine grain color neg.	**24**	**$13.95**
Ektachrome 1600, fast slide film	24	**$14.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

WRITE NO. 6 ON THE READER SERVICE CARD

ASTRO BYTES


NGCView - [NGC 3587 = Owl nebula = M 97]
File Search Configuration Database Tools Window Help
+ LIST
+ LOG
FILTER
SORT
Altitude
Chart View
URSA MAJOR

NGC 3587

Name: Owl nebula
Type: Planetary Nebula
Found Object (not on observing list)
Brightness: Very Bright
Size: Very Large
Shape: Round
Dreyer Desc.: !!, PN , vB, vL, R, vvg, vsbM, 150" d; = M97
SkyAtlas: Chart 2
Dia: 3.20 min
Uranometria: p 46 v.1
Mag: 11.2 Visual
Appar Equatorial 28FEB97 14:47:41 LMT
Constellation: Ursa Major (UMa)
Right Ascension: 11h 14m 39.63s
Declination: 55° 01' 46.40"
Appar Horizon 28FEB97 14:47:41 LMT
Alt: Low
Az: North
Rise Time: Feb 28, 1997 12:51:13 LMT
Transit Time: Mar 1, 1997 00:25:02 LMT
Set Time: Feb 28, 1997 12:02:48 LMT

Found Object (not on observing list) | 14:47 February 28, 1997 | LST 01:35

NGCView 4.3 for Windows

Observers who are ready to explore beyond the Messier list may find the 13,226 objects in the *New General Catalogue (NGC)* and *Index Catalogue (IC)* to be their next challenge. *NGCView 4.3* is an observational planning and logging system designed to help them with that next step. Using the *NGC2000.0* (an update of the *NGC*), and *IC*, it assembles an observing list quickly and easily, and creates printed observing plans, charts and graphs. *NGCView 4.3* sorts and filters calculated data such as rise/transit/set times, chart locations, visibility and observing order. It can automatically avoid objects that will be below the horizon and sort objects into an observing order optimal with which to work. And, if you wish to avoid objects you've already seen, *NGCView 4.3* will create an observing log database.

Rainman Software, 100 Shale Place, Charlottesville, VA 22902-6402; phone, (888) 261-1686; fax, (804) 984-1241; e-mail, sales@rainman-soft.com; website, http://www.rainman-soft.com. Price: $49.95 + $3 S&H ($5 outside USA). Minimum PC requirements: 386 computer, Windows 3.1 (Windows 95 compatible), mouse, and a VGA display.

Ask the Astronomer

Do you have questions about space science and astronomy but don't know who to ask? Sten Odenwald hosts the *Ask the Astronomer* website. There you will find answers to many questions, including those about the May 5, 2000 Grand Conjunction! — http://www2.ari.net/home/odenwald/qadir/qanda.html.

AstroByte Stars will be given to new astronomy/space software products that perform above and beyond similar products in the same price range, or offer unique features. Criteria for AstroByte Stars include unique design, comprehensive coverage of topics, user-friendliness, and interactive features, and generally, accessibility for both Windows and Macintosh platforms.

Space Station Simulator

Some people think space stations are the wave of the future. The International Space Station, the first such outpost designed for human habitation, is set to be completed in 2003. It is a cooperative effort by the United States, Russia, Japan, Canada, and member countries of the European Space Agency.

Space Station Simulator, a CD-ROM, allows users to modify a space station design or create new ones. Intel's MMX technology enables you to take a virtual space walk around your station and view it from any angle, or launch space vehicles such as the Space Shuttle. Navigable virtual reality interiors provide tours of your station, and "hot spots" throughout teach you how it functions. Additionally, you can explore Internet links through a dedicated website and access updated information from NASA and the Russian Space Agency.

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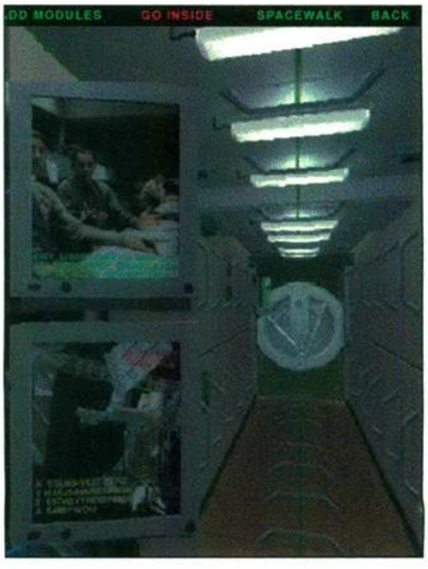

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Special Guest Speakers*:

- **Ray Arvidson**, Washington Univ., "Mars"
- **John Brandt**, Univ. of Colorado, "Comet Hale-Bopp"
- **Helene Dickel**, Univ. of Illinois, "Molecules in Space"
- **Alex Filippenko**, Univ. of California-Berkeley "Supernovae"
- **Jim Kaler**, Univ. of Illinois, "Stellar Evolution"
- **Rocky Kolb**, Fermilab, "Cosmology"
- **Mario Mateo**, Univ. of Michigan, "Dwarf Galaxies"
- **David Morrison**, NASA Ames, "The Threat of Asteroid Impacts"
- **Robert Morse**, Univ. of Wisconsin, "Neutrino Astronomy"
- **Leif Robinson**, Sky & Telescope, "Amateur Research Prospects"
- **Scott Sandford**, NASA Ames, "Meteorites from Mars"
- **Virginia Trimble**, Univ. of Maryland and Univ. of California-Irvine, "Technology & Astronomy Links"
- **Ray Villard**, Space Telescope Science Institute/Baltimore, "HST Results"

And also featuring:

- **Laura Danly**, Space Telescope Science Institute/Pomona, "Galactic Ecology"
- **Andy Fraknoi**, Foothill College, "A Skeptic's Guide to Astrology"
- **Richard Kron**, Univ. of Chicago/Yerkes Obs., "The Sloan Digital Sky Survey"
- **Seth Shostak**, SETI Institute, "The Search for Extra-Terrestrial Intelligence"
- **David Slavsky**, Loyola Univ., "The Physics of Baseball"
- Panel discussion, "Science and Religion in the Golden Age of Astronomy" with George Musser of the A.S.P., Hector Avalos of the Committee for the Scientific Examination of Religion, Kitty Ferguson – Steven Hawking biographer, and Zachary Hayes of the Catholic Theological Union

*All speakers and topics are subject to change

PLUS:

A special presentation by NASA Astronaut Steven Hawley and Doug Duncan of the A.A.S. and Adler Planetarium on the Hubble Space Telescope, Friday evening June 27.

Book signings with Don Osterbrock, former director of Lick Observatory, "The Birth, Near Death, and Rebirth of Yerkes Observatory," Rocky Kolb, Fermilab, "Blind Watchers of the Sky," William Sheehan, "The Immortal Fire Within" and "The Planet Mars" and Gale Christianson, Indiana State Univ., "Edwin Hubble: Mariner of the Nebulae."

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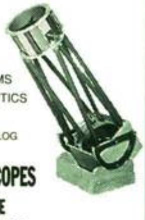

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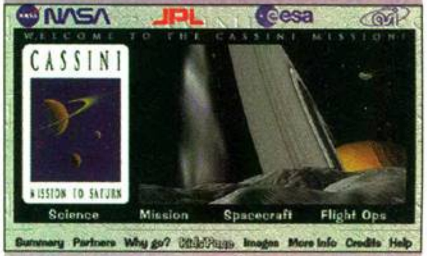

June is *Family Month* in AstroBytes.

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http://www2.ari.net/home/odenwald/cafe.html

An Astronomy Course for Students Online
http://www.cnde.iastate.edu/staff/jtroeger/astronomy.html

Berit's Best Astronomy Sites for Children
http://www.cochran.com/theodore/noframe/berit/astronomy.html

Cassini Voyage to Saturn
http://www.jpl.nasa.gov/cassini

Family Explorer
http://members.aol.com/fenews/index.htm

Fun With NASA
http://quest.arc.nasa.gov/interactive

Live From Mars
http://quest.arc.nasa.gov/mars/index.html

Nova SpaceWatch
http://www.pbs.org/wgbh/pages/nova/spacewatch/index.html

Observatorium
http://observe.ivv.nasa.gov

StarChild
http://heasarc.gsfc.nasa.gov/docs/StarChild/StarChild.html

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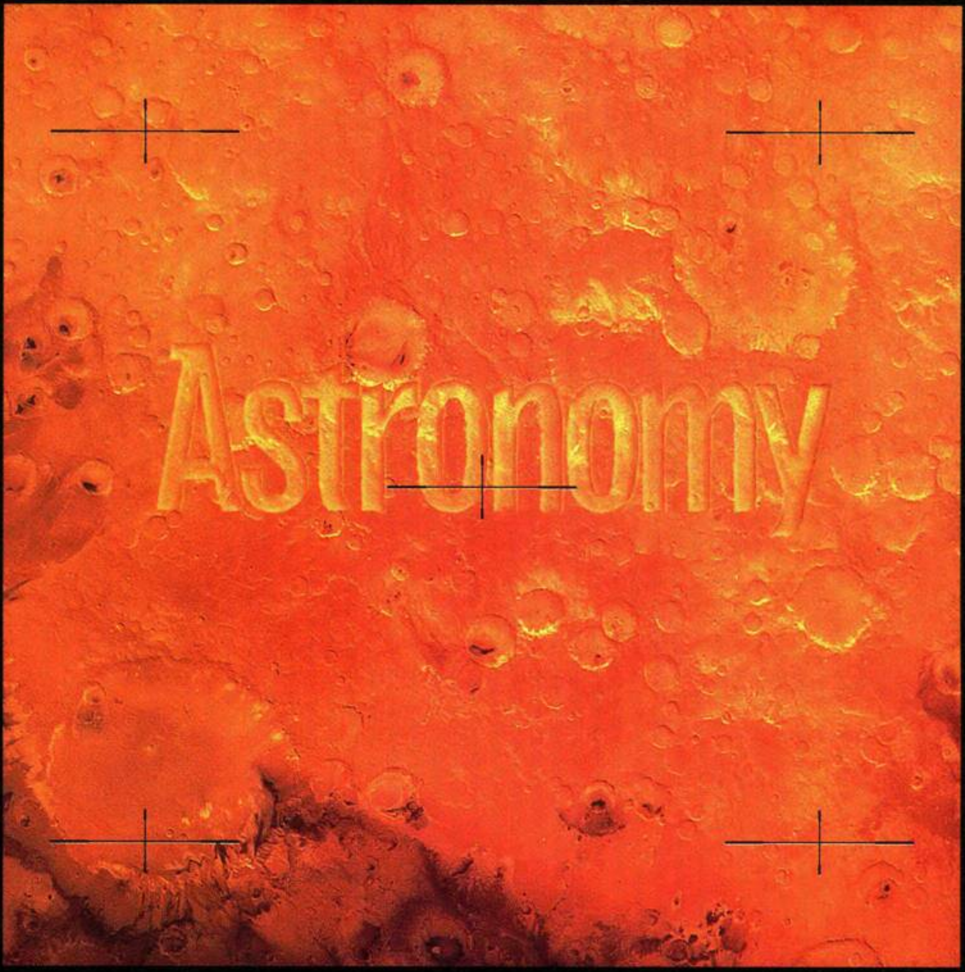
Product information is as provided by the developer. Software developers may send new programs and upgrades to AstroBytes, ASTRONOMY, *P.O. Box 1612, Waukesha, WI 53187-1612 or e-mail bytes@astronomy.com. Check out* ASTRONOMY'S *home page at* http://www.kalmbach.com/astro/astronomy.html.



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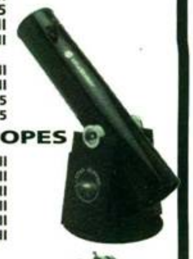

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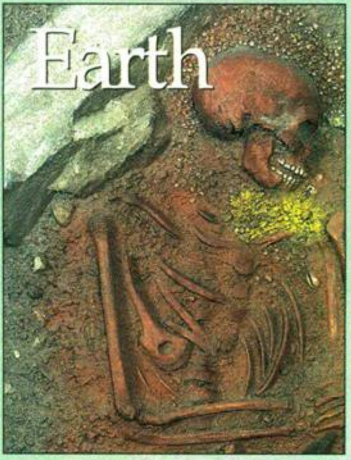

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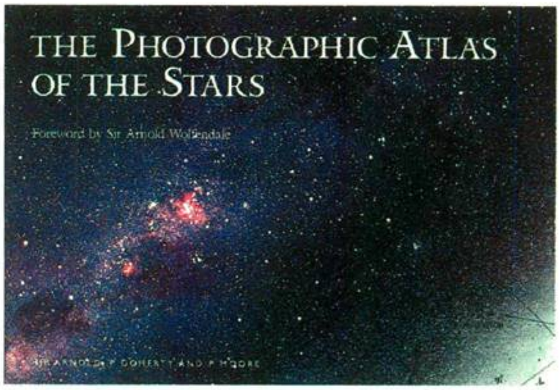
THE PHOTOGRAPHIC ATLAS OF THE STARS
Foreword by Sir Arnold Wolfendale
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The Photographic Atlas of the Stars

H. J. P. Arnold, Paul Doherty, and Patrick Moore, 220 pages, Kalmbach Publishing Co., Waukesha, Wisconsin, 1997; ISBN 0-913135-31-3, hardcover, $59.95.

Amateur and professional astronomers now have access to a true photographic atlas of the night sky. *The Photographic Atlas of the Stars*, from the publishers of ASTRONOMY and the Institute of Physics Publishing in Great Britain, presents the entire night sky in 45 full-page beautiful color photographs taken with a 35mm lens. These photos approximate what one sees with the naked eye. Each photograph is accompanied on the facing page by a star map illustrated by Paul Doherty, a skilled astrocartographer and observer.

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In the book's introduction, H. J. P. Arnold describes the methods he used to acquire the photographs. Arnold traveled extensively to dark-sky sites in both hemispheres, and he used carefully controlled photography and processing techniques.

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Other Books

The Case For Space

Paul S. Hardersen, 191 pages, ATL Press, Inc., Shrewsbury, Mass., 1997; ISBN 1-882360-47-8, softcover, $19.95.

Though space exploration was a topic of fascination for many years, the climate for funding has cooled significantly. Hardersen examines causes for this change and outlines ways in which civil space activities are of vital importance to the average citizen. The book illustrates widespread benefits of space research, from studies of African gorillas to greater understanding of global warming, and presents case studies of individuals who have benefited from medical and technological advances. Arguing that future space explorations will advance technology, foster international cooperation, and spur economic growth, and backing it up with concrete examples of the important strides already made possible by space exploration, Hardersen makes a strong case for increased space funding and research. He challenges the American public to decide in favor of its future.

The Art and Science of CCD Astronomy

David Ratledge, editor, 178 pages, Springer-Verlag, London, 1997; ISBN 3-540-76103-9; paper, $39.95.

Twelve of the finest CCD imagers in the world have contributed to this book, which is part of Springer-Verlag's Practical Astronomy series edited by Patrick Moore. CCD experts such as Tim Puckett, Luc Vanhoeck, George Sallit, David Ratledge, and Gregory Terrance fill the pages with tips and images. The book includes each contributor's e-mail address, so the experts are only a few keyboard strokes away. Whether you've been looking for a guide to CCD imaging or simply wondered if CCD imaging was your next step, this book will help steer you in the right direction.

Jupiter: The Giant Planet, Second Edition

Reta Beebe, 261 pages, Smithsonian Institution Press, Washington, D.C., 1997; ISBN 1-56098-685-9, softcover, $16.95.

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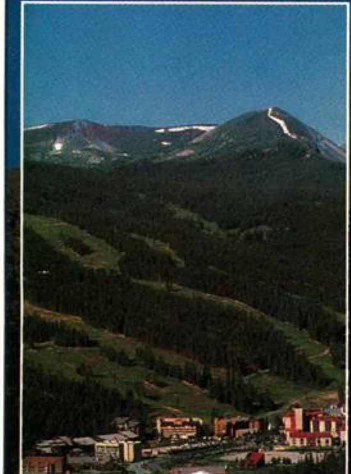

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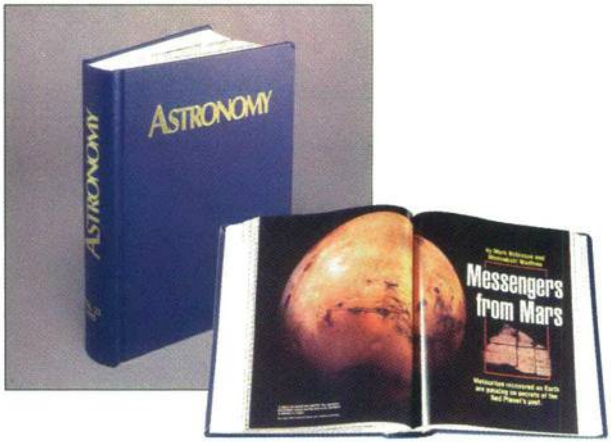

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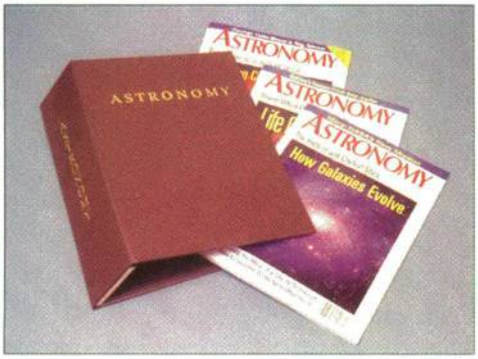

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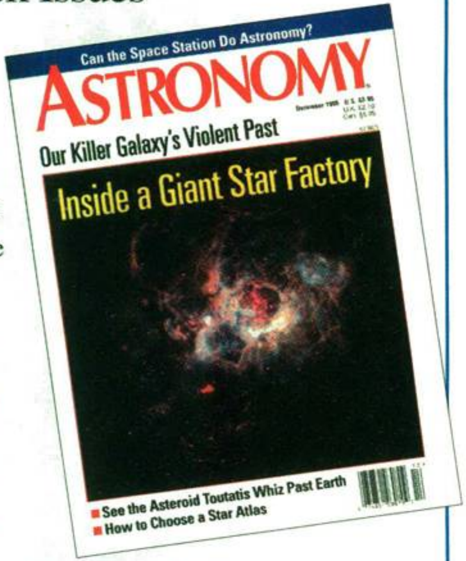
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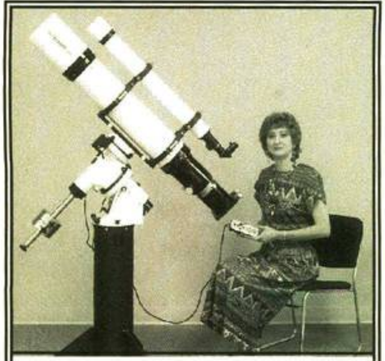

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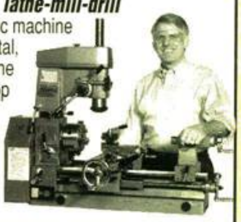

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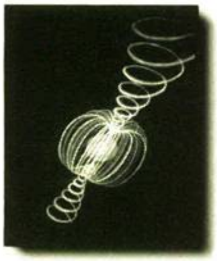

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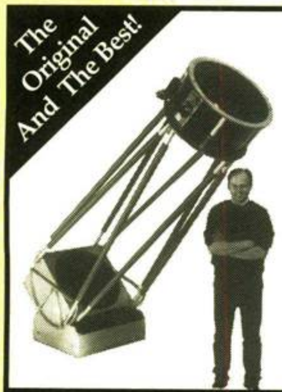

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May 30-June 1
Southern Star Astronomical Convention, Wildacres Retreat, near Little Switzerland, North Carolina. Contact Joe Baldridge, 1300 Queens Road, Apt. 301, Charlotte, NC 28207, (704) 370-6682, baldridgej@aol.com.

May 30-June 1
Wisconsin Observers' Weekend (WOW), Hartman Creek State Park, Wisconsin. Contact Don Wyman, 1065 Laager Lane, Oshkosh, WI 54901, (414) 233-3083, dwyman@vbe.com.

June-November
Sidewalk Gatherings and Star Parties, several events will be taking place in the Sequoia and Kings Canyon National Parks, Three Rivers, California. Contact Hal M. Taliaferro, P. O. Box 10, Three Rivers, CA 93271-0010, h9000@calwest.net.

June 6-7
Fiftieth Annual Convention of the North Central Region of the Astronomical League, Kenosha, Wisconsin. Contact the Racine Astronomical Society, P. O. Box 085694, Racine, WI 53408.

June 6-8
Eighth Annual Mason-Dixon Star Party, Spring Valley County Park, York County, Pennsylvania. Sponsored by the York County Astronomical Society. Contact Jeri Jones, York County Parks, 400 Mundis Race Road, York, PA 17402, (717) 840-7226.

June 6-8
Jersey Starquest VIII, Camp Linwood-MacDonald, Branchville, New Jersey. Sponsored by the Amateur Astronomers' Association of Princeton. Contact William Murray, P. O. Box 2017, Princeton, NJ 08543, (609) 298-1179, wjm@sarnoff.com.

June 6-8
Fourteenth Annual Summer Solstice Star Party, Northern Cross Observatories, Fenton, Michigan. Contact Doug Bock, Warren Astronomical Society, P. O. Box 1505, Warren, MI 48090-1505, (810) 750-0273, dougbock@kode.net.

June 7
Star Party, Craters of the Moon National Monument, Arco, Idaho. Sponsored by the Idaho Falls and Magic Valley Astronomical Societies. Contact Forest Ray, (208) 736-8678.

June 7-14
Grand Canyon Star Party, Grand Canyon, Arizona. Sponsored by the San Francisco Sidewalk Astronomers, the Tucson Amateur Astronomy Association, and the National Park Service. Contact Dean Ketelsen, 1122 East Greenlee Place, Tucson, AZ 85719, (520) 293-2855.

June 8-15
Beginning Teen Astronomy Camp, Mt. Lemmon and Bigelow Observatories, University of Arizona, Tuscon, Arizona. Contact (520) 621-7079, dmccarthy@as.arizona.edu.

June 10-14
SEPA '97 — Southeastern Planetarium Association Annual Conference, Science and Space Theater, Pensacola, Junior College, and the Hampton Inn, Pensacola, Florida. Contact Clint Hatchett, Director, Science and Space Theater, Pensacola, Junior College, 1000 College Blvd., Pensacola, FL 32504, (904) 484-2516, chatchett@pjc.cc.fl.us.

June 13-14
Twenty-Seventh Annual Apollo Rendezvous, Dayton Museum of Natural History, Dayton, Ohio. Contact Apollo Rendezvous '97, Miami Valley Astronomical Society, 2600 Deweese Parkway, Dayton, OH 45414, Terry Mann, (937) 678-5032.

June 13-15
Mid-States Meeting '97, Washington University campus, Forsythe Street, St. Louis, Missouri. Hosted by the St. Louis Astronomical Society. Contact Stephen Sands, 911 Langdon Street, Alton, IL 62002, (618) 465-1463, scopes777@aol.com.

June 21
Sun Fest: Summer Solstice, Adler Planetarium, 1300 South Lake Shore Drive, Chicago, Illinois 60605. Contact (312) 322-0304, 24-Hour Information Line (312) 922-STAR.

June 27-29
Fieldstar '97, Vernonia Peak Observatory, Vernonia, Oregon. Sponsored by the Northwest Astronomy Group and Northwest Astronomy Net. Contact Sandy Mikalow, Vernonia Peak Observatory, 55371 McDonald Road, Vernonia, OR 97064, (503) 429-2430.

June 27-29
Rocky Mountain Star Stare, Pike National Forest, Wilkerson Pass Area, Colorado. Sponsored by the Colorado Springs Astronomical Society. For more information send a SASE to RMSS'97, 8125 Avens Circle, Colorado Springs, CO 80920, DWilder@kktv.com.

June 27-July 4
Advanced Teen Astronomy Camp, Mt. Lemmon and Bigelow Observatories, Univesity of Arizona, Tuscon, Arizona. Contact (520) 621-7079, dmccarthy@as.arizona.edu. ☐

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A Friend on Mir is a Friend Indeed

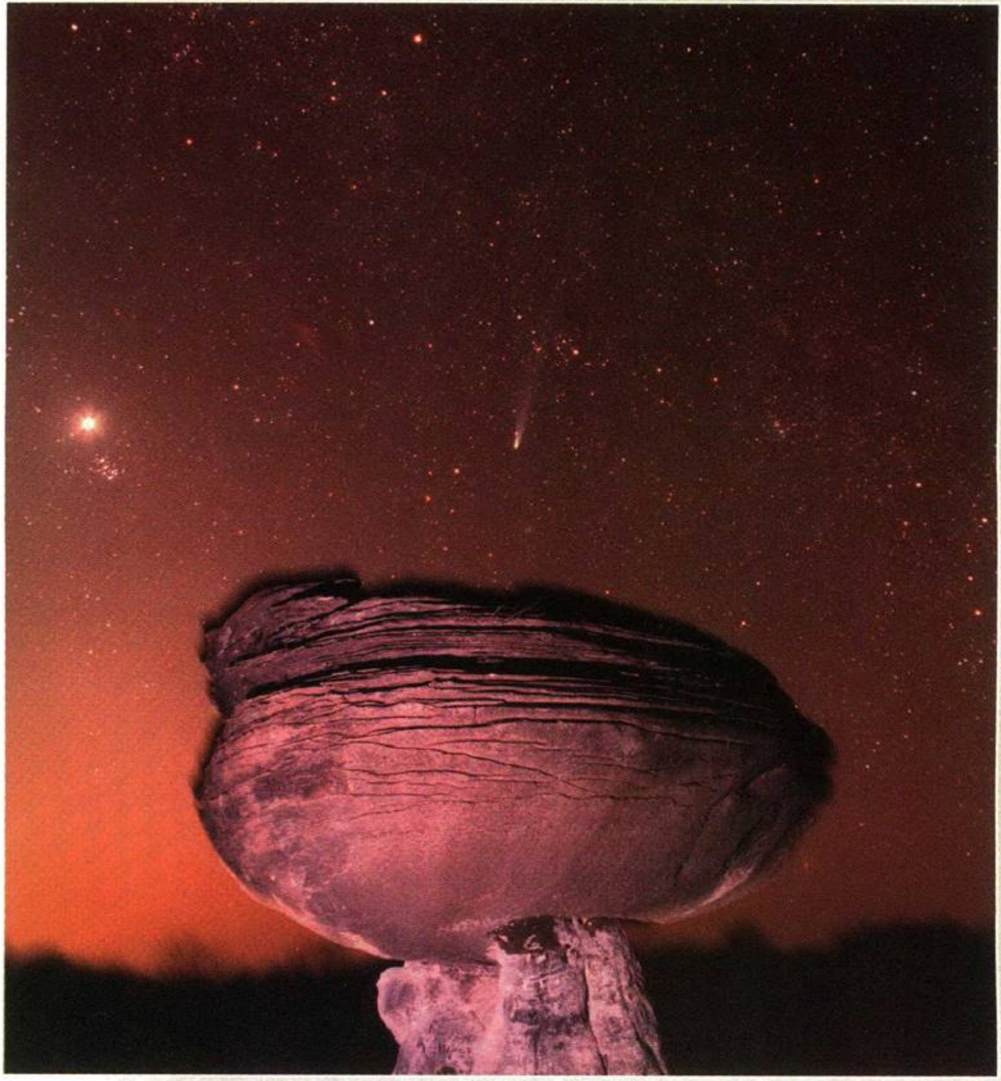
Astronomers go to great lengths to see things in the sky. Some travel continents, others hop a rocket into space, while still others do their astronomy through travellers who hop rockets to space stations. This is what two earthbound astronomy enthusiasts did last fall through Mir space station cosmonaut Aleksandir Kaleri.

Jay Flynn of Los Angeles, California, and Dave Hendrick of Claremont, New Hampshire, both amateur astronomers and avid ham radio operators, faxed regular messages to Kaleri, an amateur astronomer himself, who was on the Russian space station for seven months until last March.

Ham radio equipment was put on board Mir (the Russian word for "peace") shortly after it was launched in 1986 to help cosmonauts combat the drudgery of long-duration spaceflight. The system forms a link between crew members and radio amateurs throughout the world.

Hendrick has been entertaining crews for years with a steady stream of jokes and stories, and has even arranged sessions between schools and orbiting cosmonauts. Both he and Flynn teamed up to write computer software that sends compressed messages to MIR as it speeds overhead.

"If the crew is busy or



Comet Hyakutake, Venus, and the Pleiades over Mushroom Rock, Kansas
Douglas C. Zubenel
(24mm lens at f/4, Fujicolor Super G 400 film, 4-minute exposure with flash on foreground)

A Partially-Eclipsed Moon Rises in the Shadow of Mauna Kea
Emmanuel Denarie
(135mm lens at f/2.8, Fuji Velvia 50 film, ¼-second exposure)

asleep, they leave on a data link that allows hams to upload e-mail to a bulletin board aboard Mir during its ten minute pass," says Flynn. "Each crew is different and we try to find out quickly what they like. Alex let us know right away."

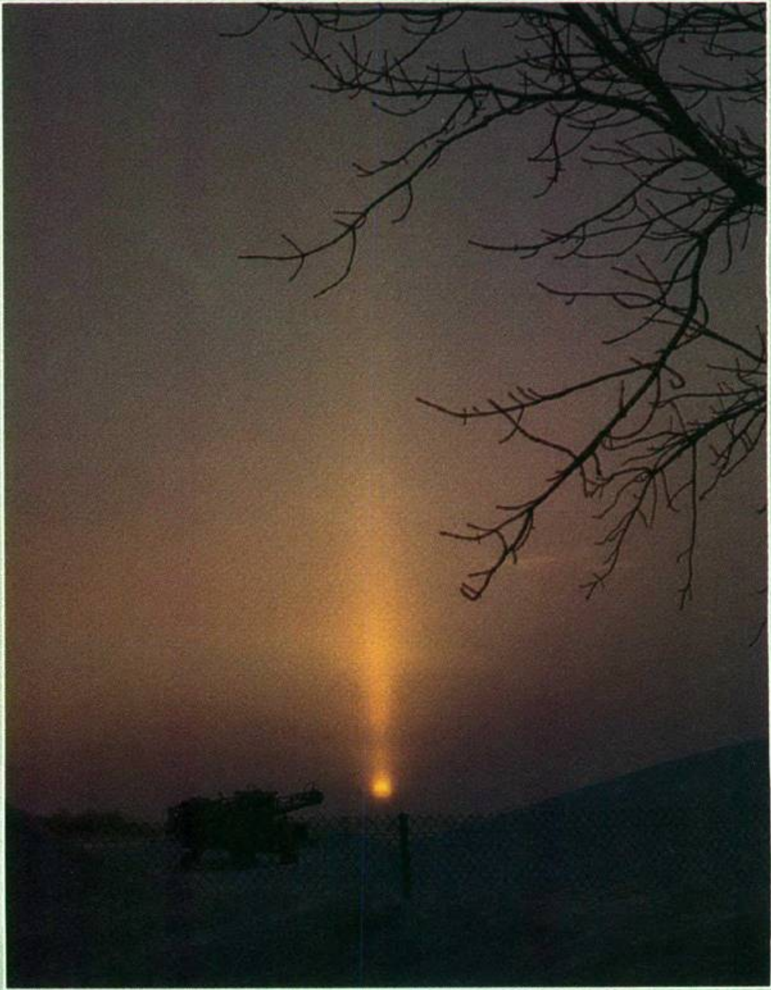
Posted : 09/29/96
Hello Jay!
Thank you for your attention. I'd like to read astronomy news. Especially comet astronomy. The most interesting comet for me is Hale-Bopp.
Thanks a lot.
Good bye.
Alex U8MIR

To get Kaleri started, Flynn and Hendrick faxed up a crude finder map for Hale-Bopp and for Comet Tabur, another visitor lighting up the fall skies. It wasn't long before Kaleri was seeing both through MIR observation ports.

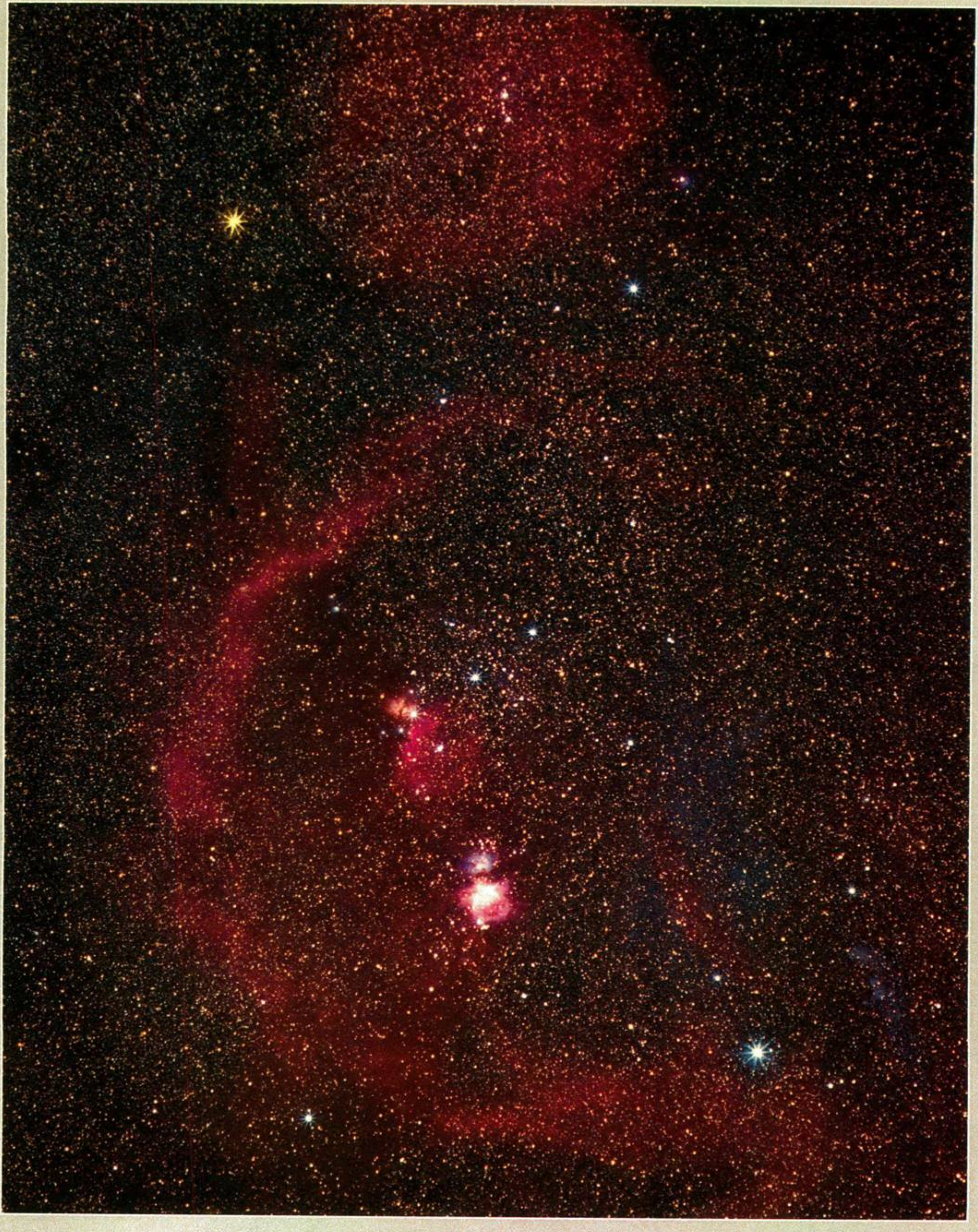
Posted : 10/10/96
Hi Dave!
I saw both Tabur and Hale-Bopp with 20x binoculars and 6x monoculars. Tabur looked like a small diffuse spot without a tail. Only the head was seen. Tonight, October 10, it was not far from Beta Ursae Majoris. Hale-Bopp was visible in binoculars and had a tail in the monoculars. I estimate its head size is 14-15 arcseconds with a tail 2 to 3 times longer. It can only be seen in our orbit during the first 10-15 minutes after we enter Earth's shadow. Then it is eclipsed by the Earth. It's a very nice scene. Thanks a lot for info and your assistance. I am so lucky to see them.
Bye.
Alex U8MIR

Kaleri's 200-mile vantage point gave him a unique way to gauge a comet's brightness against Earth's atmosphere.

Spring Stars Set over Organ Pipe Cactus
Douglas C. Zubenel
(16mm lens at f/2.8, Konica SR-V3200 film, 10-minute exposure)



Sun Pillar over Minnesota
Randall Wehler
(50mm lens at f/16, Kodak Elite II 200 film, 1/125-second exposure)



Orion Wreathed in Nebulosity
Tony and Daphne Hallas
(165mm lens at f/5.6, hypered Kodak 6x7 PPF film, composite of two 20-minute exposures)

Posted : 10/24/96
Hello Dave!

I have been comparing Hale-Bopp's brightness with Earth's first emissional layer as the comet sets. Until October 21, Hale-Bopp was about 10% brighter. On the 21st, the difference was a bit more than 5%. I don't think this means the comet's brightness has diminished. Perhaps the Earth's emissional layer has brightened due to the Orionid meteor shower. It's well known that the upper atmosphere gets dusty at this time.

Bye.
Alex U8MIR

Hendrick and Flynn continued to feed Kaleri info on Hale-Bopp right up until the comet became too difficult to see from the station. Shortly before the cosmonaut returned to Earth, he reported "It was an incredible sight," and looked forward to seeing it again on the ground. In the meantime, the two Americans have kept up their frequent contact with other cosmonauts and visitors to Mir.

"As children of the space age," says Flynn, "we never thought we would ever talk directly to someone in space. It is doubly rewarding to help someone who not only looks to the stars, but has actually taken steps toward them." ☐

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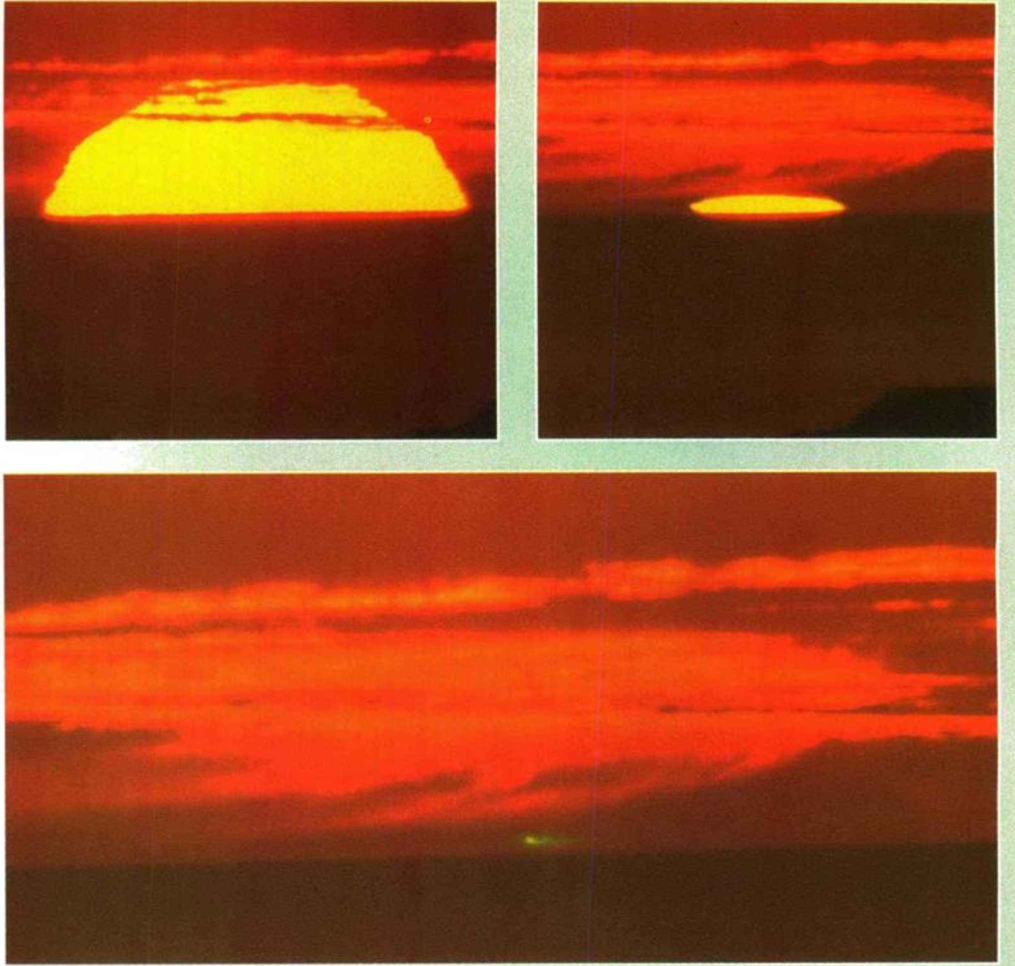
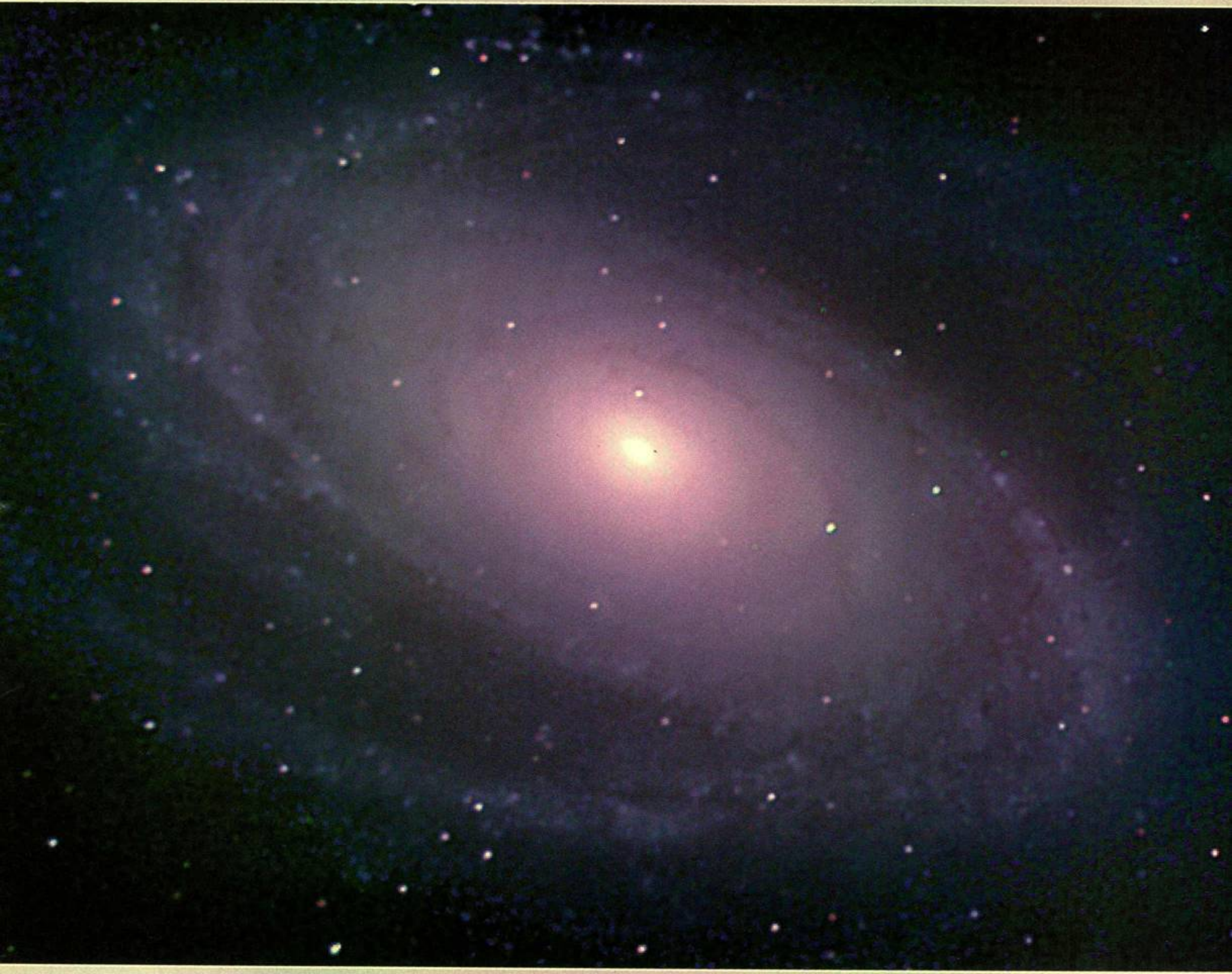


Green Flash Follows a Mediterranean Sunset
Paolo Candy
(10-inch f/6.3 Schmidt-Cassegrain telescope, Kodak Panther Chrome 50 film, 1/30-second exposures)

Comet Hale-Bopp from Mount Wilson, California
Bob Yen
(165mm lens at f/2.8, Kodak PMZ 1000 6x7 film, 7-second exposure)



Spiral Galaxy M81 in Ursa Major
Jack Newton
(16-inch Schmidt-Cassegrain telescope working at f/6.5, Meade Pictor 1616XT CCD camera, composite of 5-minute red, 20-minute green, and two 20-minute blue exposures)

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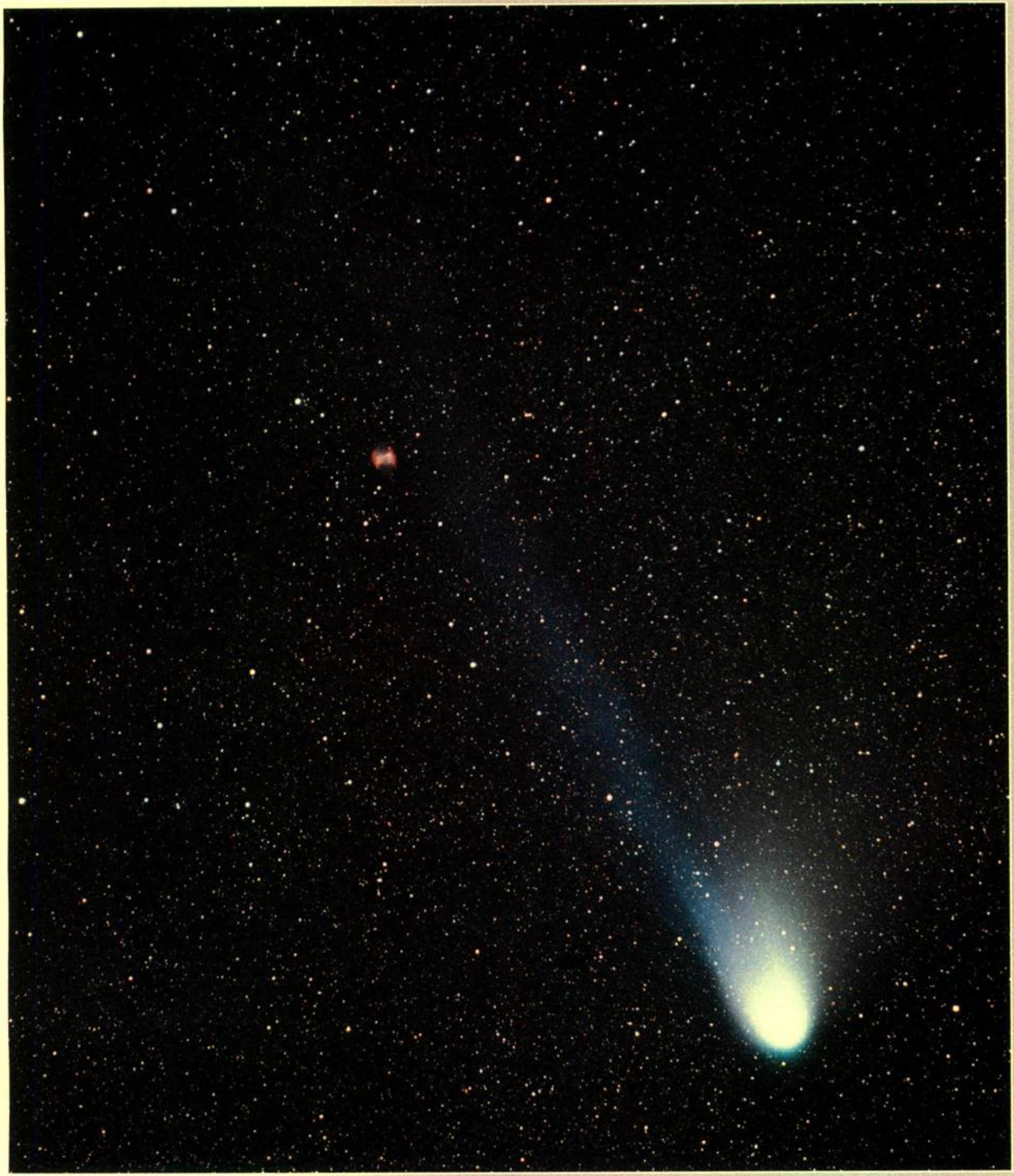

Comet Hale-Bopp Sails past the Dumbbell Nebula (M27)
John A. Volk
(4-inch f/6 refractor, Kodak PMZ 1000 film, 15-minute exposure)

Volk traveled to Joshua Tree National Park in California on February 10, 1997 to capture Comet Hale-Bopp passing through Sagitta in the predawn sky. On that morning Hale-Bopp's bluish ion tail lay in front of the outer portions of the Dumbbell Nebula (M27) in nearby Vulpecula. (The comet's fan-shaped dust tail reflects the sun's white light.) Hale-Bopp was about 117 million miles from the sun that morning; at 980 light-years, M27 is 5.7 quadrillion (million billion) times more distant.

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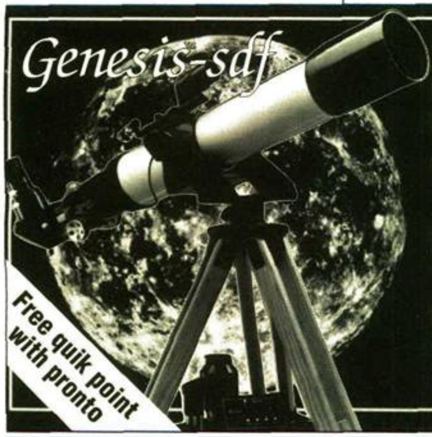

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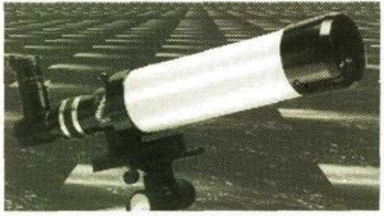

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TELE VUE...TOPS IN THE FIELD

NAGLER

82° — "Space out" with Al

The "spacewalk" eyepiece! Patented & tested to be the best! Fully multi-coated, eyeguards. 20, 16, 13, 12, 9, 7, 4.8mm

PARACORR

How to Figure a Newton

Paracorr corrects coma and flattens the field of "DobNewts," increases diffraction limited field area by 36 times and slips into a 2" focuser like a Barlow! Essential for f/4 — f/5 scopes. See perfection emerge.

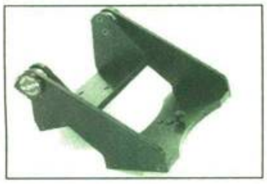
RICH FIELD KIT

SCT owners—Get Rich Quick!

No gimmicks. Maintain the optical integrity of your scope and increase its field area by 3 times with our Rich Field Kit. The kit includes adapters, 2" diagonal and 55mm Plössl for maximum true field. Use the 35mm Pan. & 20mm N2 too!

UP-SWING

How to Swing on a Star



Up-Swing threads onto any standard camera tripod to provide it with smooth and balanced vertical positioning—exactly what camera tripods lack for astronomical observing. The modified Panoramic head accepts any Tele Vue telescope 4" or smaller.

NEW PANOPTIC

Introducing the 19mm

The 68° Panoptic family welcomes the arrival of its new 7oz, 1¼" 19mm. A "killer" with Bino Vue! 35, 27, 22, 19 & 15mm

BINO VUE

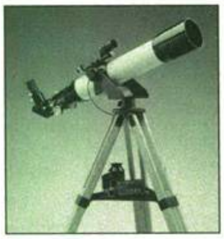
Cyclops Need Not Apply

Bino Vue features in-line viewing for terrestrial and astronomical observing, no focus shift during inter-ocular adjustment, large, multi-coated prisms and Tele Vue quality control. Dramatically transforms any scope!

GIBRALTAR/SKY TOUR

What a trip!

Rock-solid wood tripod with alt-az head. Sky Tour computer available for finding and identifying 2000 objects selected by author Tom Lorenzin. Great with all Tele Vue scopes. Full object listing included.



FIELD FLATTENER

Flatten Your Pronto/Ranger

Tele Vue
Suffern, NY

Just place between camera adapter and T-ring for knockout punchy starfield photos. The 480mm focal length extends to 520mm at f/7.4.

PLÖSSL

50° -Mr. P Would be Proud

Preferred Plössl in S&T comparison review. Fully multi-coated, patented Nagler design. 55, 40, 32, 25, 20, 15, 11, 8mm

BARLOWS

No Fat, All Muscle Power

Nagler designed for optimum performance. NO aberrations, just magnification! 2x & 3x (1¼"), 2x (2") with captive screw & parfocal 1¼" eyepiece adapter. Fully multi-coated and threaded for filters.

FINDER

Didn't Know She's Missing

Tele Vue Qwik Point

Star-hop across the sky with Starbeam and Qwik-Point "red-dot" finders. Starbeam features a large 40mm lens, variable brightness, elegant design and all metal construction. Qwik-Point offers day & variable night brightness, light weight & exceptional value.

Tele Vue products are designed, manufactured and tested to be fully appreciated where it counts — in the field.

Tele Vue®

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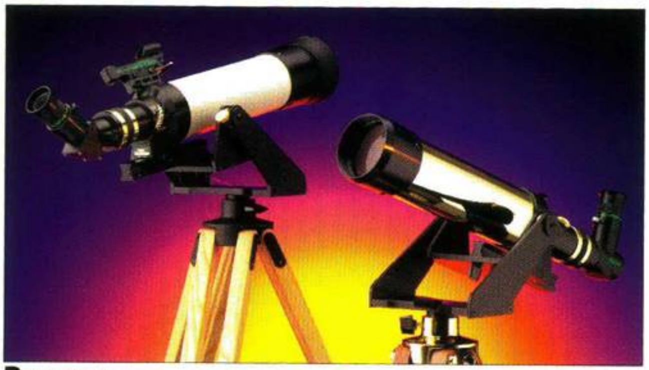
WRITE NO. 50 ON THE READER SERVICE CARD

TELE VUE RANGER & PRONTO

Heads or Tails...

Pronto photograph of Comet Hyakutake, by William Yang of Taiwan

You Win.
Get
High Power
***and* Wide Field**
with Ranger
& Pronto.



Ranger

	Ranger	**Pronto**
Objective:	2-element, E.D.	Same
Power Range:	12x - over 200x	9x - over 200x
Visual Field:	3.3°	5.5°
Photo Field:	5.2° 35mm film diag.	Same
Aperture:	70mm	Same
Focal Length:	480mm	Same
Focal Ratio:	f/6.8	Same
Focus Type:	1¼", 2 Stage with Helical	2" Rack & Pinion
Dew Shield:	Available	Captive, Sliding
Mounting:	¼-20 Balance Bar	¼-20 Mount Ring
Carry Bag:	Available	Custom Padded
Choices:	1¼" Mirror Diag., 1¼" 45°, or Porro Prisms	2" or 1¼" Mirror Diags., 1¼" 45°, or Porro Prisms
Accessories:	All 1¼" Tele Vue eyepieces 2x Barlow optimum All Tele Vue Mounts Qwik-Point 35mm Camera Adapter Padded Shoulder Bag Padded Fitted Bag Rubber Lens Shade	All Tele Vue eyepieces All Tele Vue Barlows All Tele Vue Mounts Starbeam or Qwik-Point 35mm Camera Adapter Piggy-Cam

Pronto

- *I wanted an extremely portable instrument of superb quality. I consider Pronto to be the Questar of refractors. It is of superb manufacture and the views are razor sharp with beautiful contrast. — J.B. AZ*
- *I really like the RFT/diffraction limited design. And, Pronto was within budget. I'm very pleased! Not only could I see Io's shadow clearly transit Jupiter (at 95x), but I could trace Io itself across the planet's darker limb - even in front of a lighter band of clouds. Thanks again. — B.O. IL*
- *I'm impressed. Ranger performs like a larger aperture telescope. A star test revealed perfect diffraction patterns. — A.G. TX*
- *Great optics, great machining. Spectacular low-power views; seems much larger than 70mm; lots of detail on high power Jupiter. — P.R. NY*
- *I needed a grab and go scope with guts. Ranger is an astounding instrument! My 8" can't keep up with this rascal — N.R. NE*
- *I need portability; to carry on flights - (airline crew). Pronto is a beautiful scope; my first look at Jupiter and Saturn convinced me I had made the right choice. Thank You. — P.H. Hong Kong*

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WRITE NO. 80 ON THE READER SERVICE CARD

CELESTRON® DOBS

NEW

STAR HOPPER™ 6" *and* 8"

The ***Star Hopper***™ *Dobsonians are designed for beginners yet they include many advanced features that even experienced observers will appreciate that are not available on any competitive models.*

- **6" f/8 and 8" f/6 models.**
- The **Dovetail Balance System** featured on the **Star Hopper**™ provides a smooth low friction altitude bearing that can be quickly and easily balanced when using optional accessories such as finderscopes or heavier oculars. Without proper balance, fine aiming adjustments are difficult, such as centering an object in a high power eyepiece. **Celestron** is the only company to offer an adjustable counter balance system standard on its Dobsonian telescopes.
- The **Star Hopper**™ **6"** and **8"** primary mirrors are housed in 8" and 10" ID tubes respectively. The oversized flat black anti-reflective painted tubes reduce light scatter and tube currents. These features increase image contrast and improve "seeing" when viewing planets and the Moon.
- The **V-Spectrum LTM Optical System** features a unique molded **Pyrex** mirror, **multi-coated** for increased reflectivity, that provides superior optical and thermal qualities and it is mounted on the **Pinnacle** mirror cell.
- The **V-Spectrum LTM (Low Thermal Mass)** mirror is manufactured and figured to reach the optimal marriage of weight to optical surface resulting in a mirror with 40% less mass than traditional mirrors. Reducing the mass lowers the "cool down" period required to bring the mirror to ambient temperature and leaves more time for observing. An optional fan can be placed behind the **Pinnacle** mirror cell to create a laminar flow of air over the **V-Spectrum LTM** primary mirror to optimize the mirror for planetary and high power observations.
- Our unique and heavy duty, single vane secondary mirror bracket creates minimal obstruction allowing more light to reach the primary.
- Our unique mount features a 10° angled rocker box which increases stability.
- Ultra smooth motion in both axes for easy finding and observing of objects.
- Included standard are a smooth operating 1¼" Rack and Pinion Focuser, a handy Collimation Tool, 25mm SMA (52°) Eyepiece – 1¼" (49x).
- Numerous accessories are available including various pointing aids — from a traditional 6x30 Finderscope, to a state-of-the-art zero power red dot pointing device — the **Star Pointer**, to the Astro Master® models to computerize your telescope.
- Manufactured at Celestron's factory in the U.S.A.
- All of the above features and yet an economical price.

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STAR HOPPER
STAR HOPPER

CELESTRON EQUATORIAL NEWTONIAN TELESCOPES

C4.5 Its 900mm focal length (f/7.9) optical system is housed in an aluminum tube. The mirrors (primary and secondary) have multi-coatings for improved contrast and resolution. The premium optics are manufactured in Japan to rigid **Celestron** specifications.

The **C4.5** uses the Polaris mount which is a very rigid German equatorial type. The very rigid wood tripod is fixed in height for added stability and is supplied with an accessory tray. A quote from *Astronomy Magazine*, "the **C4.5** stands out from the pack by having by far the best mount. Its Polaris mount is wonderful. Solid. Smooth. And with a damping time of two seconds. It was a joy using this telescope." "This is a first-rate telescope that outclasses the competition in the popular 4½" class of Newtonians." Further they said, "the C4.5 star images were classic textbook Airy disks".

Standard accessories include a 26mm multi-coated Plössl Eyepiece – 1¼" (35x), high quality 6x30 Finderscope and a 1¼" Focuser.

Firstscope 114 Its 910mm focal length (f/8) optical system is housed in an aluminum tube. This high quality yet economical telescope is made in a modern, high quality telescope factory in China to **Celestron's** specifications.

The equatorial mount is stable and includes setting circles in both axes as well as slow-motion cables in both axes for easy tracking. The wood tripod is adjustable in height and includes an accessory tray.

Standard accessories include a 5x24 Finderscope, 1¼" Focuser (with a .96" adapter), 20mm H–.96" Eyepiece (46x), 4mm SR–.96" Eyepiece (228x), 2x Barlow Lens –.96"

A **Firstscope 114 Deluxe** model is available which replaces all .96" accessories with two high quality 1¼" eyepieces – 25mm SMA (36x) and 10mm SMA (91x). The 1¼" accessories give you sharper views, a wider field of view and better eye relief.

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For more detailed information on these telescopes, contact a Celestron dealer or Celestron.

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